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COMPUTER EVALUATION OF THE ON-AND-OFF DESIGN PERFORMANCE OF AN --ETC(U)

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

COMPUTER EVALUATION OF THE ON-AND-OFF-DESIGN PERFORMANCE OF AN AXIAL AIR TURBINE

by

Robert Cirone

March 1981

Thesis Advisor R. P. Shreeve

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An existing code for calculating axial turbine performance using multiple stream surfaces was modified and made to run on the equivalent of an HP-1000 computer system. Calculations were made for the geometry of a 485 horsepower dual-discharge air-drive turbine for both on and off-design conditions. The results were compared with available data obtained at off-design speeds. Agreement of the flow rate and horsepower to within 5% was obtained.

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Computer Evaluation of the On-and-Off-Design Performance of an Axial Air Turbine

by

Robert Cirone
Lieutenant, United States Navy
B.S.M.E., University of Notre Dame, 1973

Submitted in partial fulfillment of the
requirements for the degree of

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March 1981

Author: Robert Cirone

Approved by: Raymond P. Shreeve
Thesis Advisor

Paul F. Pucci
Second Reader

P. J. Marto
Chairman, Department of Mechanical Engineering

William M. Tolles
Dean of Science and Engineering

ABSTRACT

An existing code for calculating axial turbine performance using multiple stream surfaces was modified and made to run on the equivalent of an HP-1000 computer system. Calculations were made for the geometry of a 485 horsepower dual-discharge air-drive turbine for both on and off-design conditions. The results were compared with available data obtained at off-design speeds. Agreement of the flow rate and horsepower to within 5% was obtained.

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LIST OF SYMBOLS

A	Cross sectional area
a	Blade opening
c	Blade chord
c_p	Specific heat at constant pressure
D	Diameter
E	Kinetic energy
g_c	Universal gravitational constant
H	Total enthalpy
H***	Energy parameter, boundary layer
h	Static enthalpy
h	Blade height
HP	Horsepower
I	Integrand
J	Conversion factor
K_{is}	Head coefficient
L	Distance between stations
M	Mach number
$\dot{m}$	Mass flow rate
m	Exponent used in boundary layer calculations
$\dot{m}_{ref}$	Reference flow rate
N	Rotational speed
P	Pressure (Psia)
R	Gas constant for air

R	Radius
r	Radius
r*	Theoretical degree of reaction
s	Entropy
s*	Non-dimensional entropy
T	Temperature (°R)
t	Maximum blade thickness
t_e	Trailing edge thickness
U	Peripheral velocity
u	Velocity within the boundary layer
V	Absolute velocity
W	Relative velocity
X	Non-dimensional radius (r/r_m)
Y	Non-dimensional axial velocity ratio (V_a/V_{am})
y	Pressure loss coefficient

GREEK LETTERS

α	Absolute gas outlet angle
β	Relative gas outlet angle
γ	Specific heat ratio, c_p/c_v
δ	Boundary layer thickness
δ	Referred pressure ratio ($P_{to}/14.7$)
δ^*	Boundary layer displacement thickness
δ^{***}	Boundary layer energy thickness
ξ	Loss coefficient
η	Efficiency

θ	Referred temperature ratio, $\frac{T_{TO}}{518.4}$
κ	Curvature factor
λ	Angle of flow in a meridional plane
§	Area restriction factor
ρ	Density
Φ	Non-dimensional flow function
ω	Angular velocity

SUBSCRIPTS

a	Axial
ACT	Actual or computed value
E	An equivalent thermodynamic quantity
eff	Effective
H	Hub
is	Isentropic
m	Mean streamline value
p	Profile
R	Relative flow value
r	radial
ref	Referred value
req	Required
s	secondary
TH	Theoretical value
TO	Total conditions
u	Tangential
o	Station at the stator inlet

1	Station between the stator and the rotor
2	Station at the rotor outlet

I. INTRODUCTION

A. DESCRIPTION OF THE TRANSONIC COMPRESSOR TEST RIG

The Transonic Compressor Test Rig at the Turbopropulsion Laboratory (TPL) of the Naval Postgraduate School is shown schematically in Fig. 1 and consists of the following major components:

1. Air drive turbine.
2. Air supply system.
3. Associated piping including throttling valves at the turbine and compressor inlets.
4. Test compressor.

The drive turbine is a dual-flow axial air turbine with 50% reaction. The geometry is given in Table 1. The profile shapes of the turbine rotor and of the stator blades are identical and the blades are of constant section along the radius as shown in Fig. 2. The stator has 31 blades while the rotor has 32 (to avoid resonant excitation from wake interference). The two parallel stages of the turbine are designed for the following output and total inlet conditions:

Pressure Ratio: 2.8

Total Inlet Temperature: 640°R

Flow rate: 10.85 LBM/SEC

Horsepower: 485 HP

The compressor presently under test is a transonic single stage, axial flow compressor. It is instrumented for measurements of torque, mass flow rate, stagnation temperatures and pressures, case and hub wall pressures, and for unsteady pressure measurements in the flow field and at the walls.

The Air Supply System incorporates an electric motor-driven multi-stage axial flow compressor manufactured by Allis-Chalmers. It can presently supply up to 12 lbs/sec of air at 3 atmospheres, at temperatures between 560°R and 660°R. The compressor is rated at 1250 HP and has a controlled variable speed drive.

B. STATEMENT OF THE TASK

The Transonic Compressor Test Rig was designed to provide the means for obtaining experimental data in fundamental compressor phenomena. Following the present experiments, an experiment to investigate the onset of supersonic unstalled blade flutter is planned which would involve replacing at least the present compressor rotor by a rotating cascade of flat-plate blades. Such a rotor would not be able to produce the pressure ratios required to pump the required flow rates through the system. Therefore, it has been proposed, that a turbocharger compressor be fitted in series with the rotating cascade to provide the required flow through it. The turbocharger would also be driven using air from the Allis-Charmers air supply system.

In order to evaluate the feasability of the turbocharger installation, it is necessary to determine the mass flow rate required by the drive turbine to drive the test compressor at a given power and speed. The remaining air to drive the turbocharger turbine is then known and the selection of a commercially available turbocharger suitable for this application can be made.

Thus, the performance of the air drive turbine must be known over the complete speed range. Of particular importance, are the required mass flow rates for given values of horsepower. The problem, therefore, is to obtain the turbine performance map for all pressure ratios and speeds.

II. APPROACH

A. BACKGROUND

A search of the most recent literature revealed a number of analytical methods for the calculation of turbine off-design performance. The majority of these used in a finite element approach but little information on the relative success of these methods in practice was available. Two alternate methods, both used at the Turbopropulsion Laboratory, were those of M. H. Vavra and E. Macchi. Each was examined in detail.

The method of Vavra, given in Ref. [1] is a one-dimensional (meanline) approach using mathematical modelling and experimental data to express flow angles and losses. It is primarily a method to design turbine blading but may also be used to predict turbine performance for a given set of gas inlet and operating conditions when the blading geometries are specified. It is assumed that the axial velocity is constant along the blading from hub to tip. Vavra states that this assumtion is reasonable for blading in which the tip-to-hub ratio is equal to or less than 1.15. The ratio is 1.312 and 1.424 for the drive turbine stator and rotor blading respectively. It was thought therefore, that the method of Macchi might yield more accurate predictions.

Macchi's method is given in Ref. [2]. The method, implemented by Macchi in a computer program written for the IBM 360, was an extension of the work done by R. Eckert [Ref. 3] and R. Harrison [Ref. 4]. Eckert wrote a program, following a simplified three-dimensional analysis, which could be used to predict the performance of a single-stage axial flow turbine. Harrison improved the program by modifying the analysis to take into account streamline curvature. Both programs were based on the three-dimensional method developed by Vavra in Ref. [5]. Macchi's principle improvements to the program were to introduce the choice of various methods to calculate gas outlet angles and loss coefficients. Two methods of calculating gas outlet angles are included; those of Ainley and Mathieson [Ref. 6] and Traupel [Ref. 7]. Five methods for calculating the loss coefficients can be selected; those due to Ainley and Mathieson [Ref. 6], Dunham and Came [Ref. 8], Balje [Ref. 9], Lonherr and Carter [Ref. 10] and Traupel [Ref. 7].

Macchi's computer program, as documented in Ref.]2], was selected for performance predictions of the drive turbine. It should be noted that no card deck of the program was available, and no results of using the program were available other than those included in Ref. [2].

B. ANALYSIS

The method requires the following assumptions;

1. There are an infinite number of blades in each blade row so that blades downstream do not affect upstream conditions.

2. The flow is axisymmetric at locations where the equation of motion is solved.

3. The flow is steady and adiabatic. Thus, the total enthalpy through the stator remains constant along a streamline and the relative total enthalpy through the rotor remains constant along a streamline.

4. All equations are solved at between blade row locations. Increases in entropy occur in the blade row upstream of the stations where equations are solved and the entropy change along a streamline between blade rows is zero.

5. The boundary layers on the turbine casing are not accounted for.

The method of solution is as follows:

1. Assume initial radial positions of the streamlines.

2. Obtain the axial velocity distribution by solving the equation of motion at the stator outlet. The velocity distribution into the stator is assumed to be axial, and uniform

3. Obtain stator loss coefficients.

4. Check overall continuity and adjust the inlet Mach number as necessary.

5. Check the between-streamline continuity, and adjust streamline radial positions as necessary.

6. Repeat this process for the rotor.

7. Re-cycle all the above calculations, accounting for streamline curvature, and repeat until convergence is reached.

C. METHOD OF SOLUTION

The computer code written by Macchi was originally run on the IBM 360 computer. The program consisted of a deck of over 2000 program cards plus over 60 data cards. Since the deck could not be located, it was necessary to re-type the program from the listing in Macchi's paper. However, since the IBM 360 computer was soon to be replaced in the period in which the work was to be carried out, an alternate computer was sought.

The HP-1000 series mini-computer located at TPL was selected for two reasons. First, the machine used FORTRAN as did Macchi's program. Secondly, it would be a benefit to TPL to have the program immediately available on the laboratory computer.

The first steps were to analyze Macchi's program, in detail, and then to run it using his example input/output. In analyzing the program it became obvious that the computer program listing given in Ref. 2, was not the one used to obtain the listed output. Numerous discrepancies were found in the listing, some of which would have prevented the program from running; others would have caused incorrect results to be obtained. A listing of these discrepancies is contained in Appendix E. When the program was understood and flow-charted, it was keyed-in at the HP-1000 computer terminal. However, modifications were required to accomodate

the program within the mini-computer disc-based operating system.

D. MODIFICATION TO THE COMPUTER CODE

Since there was no card reader, variable input data such as turbine speed had to be entered using data or specification statements. This contributed in part to the most difficult problem, that of program size. The HP-1000 mini-computer uses a disc with a storage capability of 19.5 mega-bytes. However, the machine memory is only 124 K Bytes, of which only 29 K Bytes is available to a programmer. Also, the available memory is divided up, or partitioned into two 18 K and one 11 K partitions, so that no single program can exceed 18 K. It was estimated that Macchi's program was over 100 K. So it was clear that the program would have to be modified if it were to run on the mini-computer.

The first modification was to remove all subroutines from the program that were not actually used. It will be recalled that Macchi's program contained five methods for calculating loss coefficients and two methods for calculating gas outlet angles. It was decided that only the Traupel method of calculating loss coefficients would be retained. Traupel was selected for two reasons. Firstly, it was the method used by Macchi in his example calculations and therefore the modifed program should still reproduce Macchi's results. Secondly, the method of Traupel is widely respected.

The method of calculating gas outlet angles was totally changed. Neither Ainley and Mathieson [Ref. 6] nor Traupel [Ref. 7] was used. Both methods required prohibitively large sections of computer code. The method selected was that of Vavra [Ref. 1].

Use of Vavra's method greatly simplified the program because this method predicts gas outlet angles independently of the inlet Mach number. Macchi's approach was to use Traupel's method which is dependent on the Mach number of the flow into the blade.

The above simplifications reduced the program size from 2257 lines to less than 1800 lines. However, this was still too large and the program could not be loaded without overflowing the memory.

The solution to the problem was found in program segmentation. In this process, the computer code is divided into a main program and several segments. Each segment is a "piece" of the original program. The segments are individually compiled and loaded. However, the segments are placed into memory only as they are needed to execute the overall program. Thus, a very large program can be made to run in the available 18 K partition. Since the present program was not originally intended for a mini-computer, segmentation was not straight forward. The method finally arrived at is detailed in Appendix C. Basically, the main

program consists of all the subroutines, while the three other segments contain coding which enables program flow to proceed in a logical manner.

Successfully segmented, the program was run using Macchi's input. An output was obtained which agreed almost exactly with Macchi's results. All output quantities were within 1% of Macchi's quantities. The differences were, in all probability, due to the different method of calculating gas outlet angles.

After verifying Macchi's program, the drive turbine geometry was input and the program was run for a given set of operating conditions. The results are discussed in the following section. Note: The "verification" of Macchi's program amounted to verifying that the computer code now loaded into the HP-1000, was indeed Macchi's code. It was not known whether Macchi's output data were a good or bad prediction of performance since they were not compared with test results.

III. RESULTS OF AXIAL TURBINE PREDICTIONS

A. USING BOTH COMPLETE AND MODIFIED PROGRAMS

The drive turbine geometry was input and the following solution flow path was selected:

1. Stator and rotor loss coefficients were functions of pressure ratio.

2. The blockage factor, ξ^*, used in the equation of continuity was equal to the total loss coefficient.

Four operating points were selected to test the validity of the program. Three were off-design points at which measured data were available and the fourth was the design point itself. Table II contains details of the selected test points for Run 1.

The program variables were then changed and the following new solution flow path was selected:

1. Stator and rotor loss coefficients were those calculated by Traupel's method.

2. The blockage factor, ξ^*, was equal to the profile loss coefficient.

After reviewing the results of Runs 1 and 2, a further modification was made to the program. The original program contained a subroutine which checked between-streamline continuity. If the total mass flow rate at the stator and rotor exits was not evenly divided between the five streamlines,

the radial positions of the streamlines were adjusted and all steps were recalculated using the new streamline positions. Hence, for Run 3, a subroutine was removed and the main program was modified so that between-streamline continuity was not examined.

B. COMPARISON WITH MEASURED DATA

The results of Run 1, 2, and 3 are tabulated in Table III. Run 1 showed predictions of mass flow rate which departed about 6% from the measured data. However, the horsepower predictions were off by as much as 16.17%. Furthermore, the computer program was unable to reach a solution for the design point.

Run 2 produced worse results as is evident from the table. Again, the program was unable to converge to a solution at the design point.

Run 3 produced more acceptable data. Additionally, convergence to a solution was noticeably faster and a solution was obtained at the design point. Because of this, the method used in Run 3 was used to map the drive turbine performance. The computer program used to obtain the results of Run 3 is described in detail in Appendix A and is listed in Appendix G. The results of Run 3 are shown plotted in Figures 3 through 8.

To obtain the plots in Figures 3 and 6, a value of the total inlet temperature was approximated by the method of Vavra as contained in Ref. [14]. It was assumed that the static turbine discharge temperature should not be less than

45°F (505°R). This corresponds to the approximate temperature at which condensation of moisture in the air, assuming 100% relative humidity, will occur. The inlet temperature was given by

$$\text{Total Inlet Temperature} = \frac{\text{Static Outlet Temperature}}{1 - \eta_s\left[1 - \left(\frac{1}{\delta_T}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

where η_s, the total-static turbine *efficiency* was assumed to be 81%, and δ_T, was the total to static pressure ratio. The total inlet temperature corresponding to each pressure ratio is given in Table IV.

The computer output corresponding to each point on Figures 3 through 8 is contained in Appendix F. Only one side of the dual flow turbine was analyzed, thus, the resulting printed values of horsepower, referred horsepower, moment, referred moment, flow rate and referred flow rate must be doubled to obtain the actual turbine characteristics which have been plotted in Figures 3 through 8.

IV. DISCUSSION

The agreement of both the predicted flow rate and the horse-power obtained in Run 3 with turbine test data was encouraging. It is to be noted however, that this agreement was obtained using a procedure which was conceptually incorrect. In Runs 1 and 2, between-streamline continuity was checked and the streamlines were adjusted as necessary. In Run 3, between-streamline continuity was not checked, and as a result, the mass flow rate between streamlines was not precisely 25% of the total flow rate. It is noted however, that the deviations were less than 10.0% and while the radial positions of the streamlines varied by 10.%, the differences between predicted and measured output horsepower decreased from 24% to 4.5%. Since the enthalpy change on each streamline was computed using Euler's turbine equation, the total horsepower obtained by integration is sensitive to the streamline radial positions. On the other hand, the calculation of the overall mass flow rate is primarily a function of the blade throat openings and inlet conditions of the flow. Consequently, in relaxing the requirement for between-streamline continuity, the output horsepower was changed significantly, while the overall flow rate was not.

Using this procedure, which preserves overall continuity, a performance map for the turbine was produced (Fig. 3-8) which agreed well with the off-design performance measurements made at lower speeds (Table III). It is noted however, that the inability of the program in its original form to predict the measured turbine performance is not explained, and both the program itself and the data input for the geometry should be closely re-examined.

The difficulty in obtaining convergence to a solution at some operating points above the pressure ratio of 2.0 is likely to be the result of choking occurring on one or more of the streamlines. This was suspected but not fully explored.

Finally, although the program was eventually made to run on the mini-computer, the time required to put the program into its final form was excessive since the original program was not written with segmentation in mind. When the segmented program was completed, only one operating point per run could be obtained. Thus, excessive time was spent compiling and loading the program. The execution time for the program averaged 2 minutes at the lower pressure ratios and up to 30 minutes at the higher ones. This would be unacceptable if many points were to be examined.

V. CONCLUSIONS

The program for calculating the performance of a single stage axial turbine reported by Macchi was revised, corrected and segmented and made to run on the Laboratory mini-computer. When applied to the geometry of the air-drive turbine of the compressor test rig, selecting specific options for the representation of loss coefficients, the revised program failed to converge when design-point test conditions where input. Also, the computed horsepower was in error by as much as 24% when the program predictions were compared with specific test data obtained from the rig at off-design (lower speed) conditions. The revised program did however closely reproduce the results given by Macchi in his original report for a specific turbine geometry.

When the requirement that the computed stream surfaces be such that they divided the flow exactly into equal 25% increments was removed, the program converged satisfactorily for design point conditions and gave agreement with test data to within 5% in flow rate and horesepower at off-design conditions.

The complete performance map for the air drive turbine was obtained with the program following this revision. Based on the favorable comparison with data so far obtained, the map is likely to describe the performance to better than a 10% uncertainty. This is considered to be satisfactory for

sizing the turbocharger for the proposed compressor rig modification.

The following recommendations are made concerning further application or development of the computer program:

1. The failure of the program to converge before the final revision was made should be analysed closely, and the final revision removed if possible.
2. The geometrical input for the air drive turbine (which was taken from drawings) should be reexamined and the physical dimensions of the blade rows themselves should be measured.
3. Consideration should be given to putting the corrected original version of the program onto the IBM 370 computer so that, when successfully operating, a turbine map can be calculated with a single load.

TABLE I

TURBINE GEOMETRY

(see Figure 2; Dimensions in inches)

STATOR:

Hub Radius	2.764
Mean Radius	3.196
Tip Radius	3.627
Blade Chord	1.003
Blade Suction Side Radius of Curvature	2.8065
Maximum Blade Thickness	.2252
T.E. Projected Thickness	.03
T.E. Normal Thickness	.0186

ROTOR:

Hub Radius	2.693
Mean Radius	3.265
Tip Radius	3.837
Blade Chord	1.003
Blade Suction Side Radius of Curvature	2.8065
Maximum Blade Thickness	.2252
T.E. Projected Thickness	.03
T.E. Normal Thickness	.0186
Tip Clearance	.01(estimated)

TABLE II

MEASURED/DESIGN DATA USED TO VERIFY THE PROGRAM

POINT	RPM	T_{IN} (R)	T_{OUT} (R)	P_{TO} (PSI)	P.R.	$M(\frac{LBM}{SEC})$	H.P.
1	18310	579.2	550.8	23.56	1.602	5.542	110.1
2	15200	557.4	517.8	20.43	1.390	4.698	63.27
3	21300	578.9	506.8	27.13	1.846	7.033	172.0
4*	30500	640.0	---	41.16	2.8	10.85	485

*Design Point

TABLE III

COMPARISON OF PREDICTED TURBINE PERFORMANCE
VS MEASURED PERFORMANCE

RUN I

	FLOWRATE			HORSEPOWER		
POINT	PREDICT.	MEAS.	%DIFF.	PREDICT.	MEAS	%DIFF.
1	5.88	5.542	6.09	99.5	110.1	9.63
2	4.74	4.698	0.89	52.5	63.27	16.17
3	7.04	7.033	0.009	163.64	172.0	4.86
4	N.C.	10.85	---	N.C.	485	---

RUN 2

1	6.06	5.542	9.35	90.92	110.1	17.4
2	4.90	4.698	4.29	49.76	63.27	21.35
3	7.30	7.033	3.80	130.76	172.0	23.97
4	N.C.	10.85	---	N.C.	485	---

RUN 3

1	5.82	5.542	5.01	113.12	110.1	2.74
2	4.66	4.698	0.81	61.96	63.27	2.09
3	7.04	7.033	0.10	179.68	172.0	4.47
4	10.40	10.85	4.15	444.18	485	8.42

NC: Computer program would not converge to a solution after a large number of iterations.

TABLE IV

VALUES OF ASSUMED TOTAL INLET TEMPERATURE FOR EACH PRESSURE RATIO GIVEN IN FIGS. 3, 5, 6, AND 7

PRESSURE RATIO	TOTAL INLET TEMPERATURE (°R)
1.4	545.5
1.6	562.6
1.8	577.3
2.0	591.0
2.2	603.6
2.4	615.3
2.6	626.1
2.8	636.6

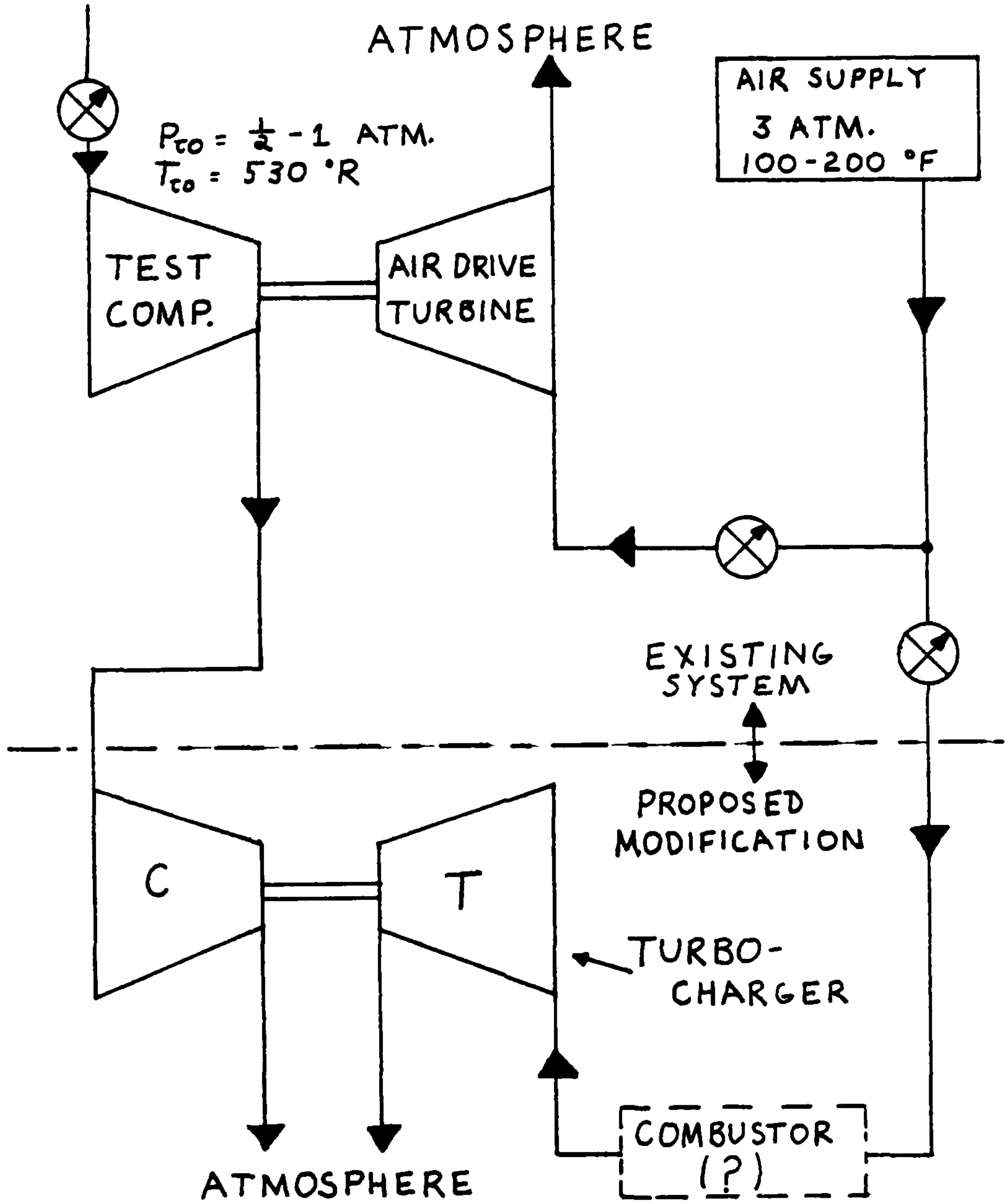


FIGURE 1: SCHEMATIC OF THE COMPRESSOR TEST RIG, WITH PROPOSED MODIFICATIONS

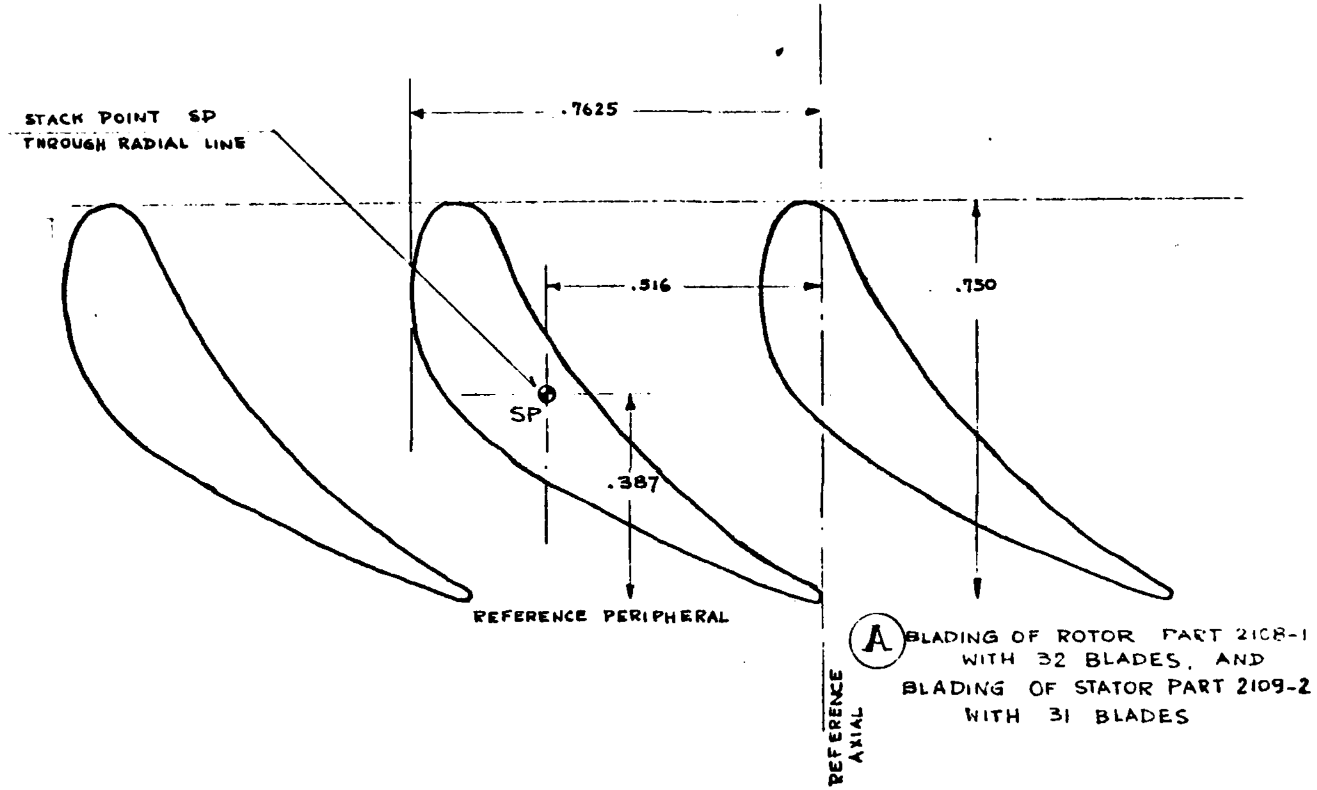


FIGURE 2: TURBINE ROTOR AND STATOR BLADE SHAPES

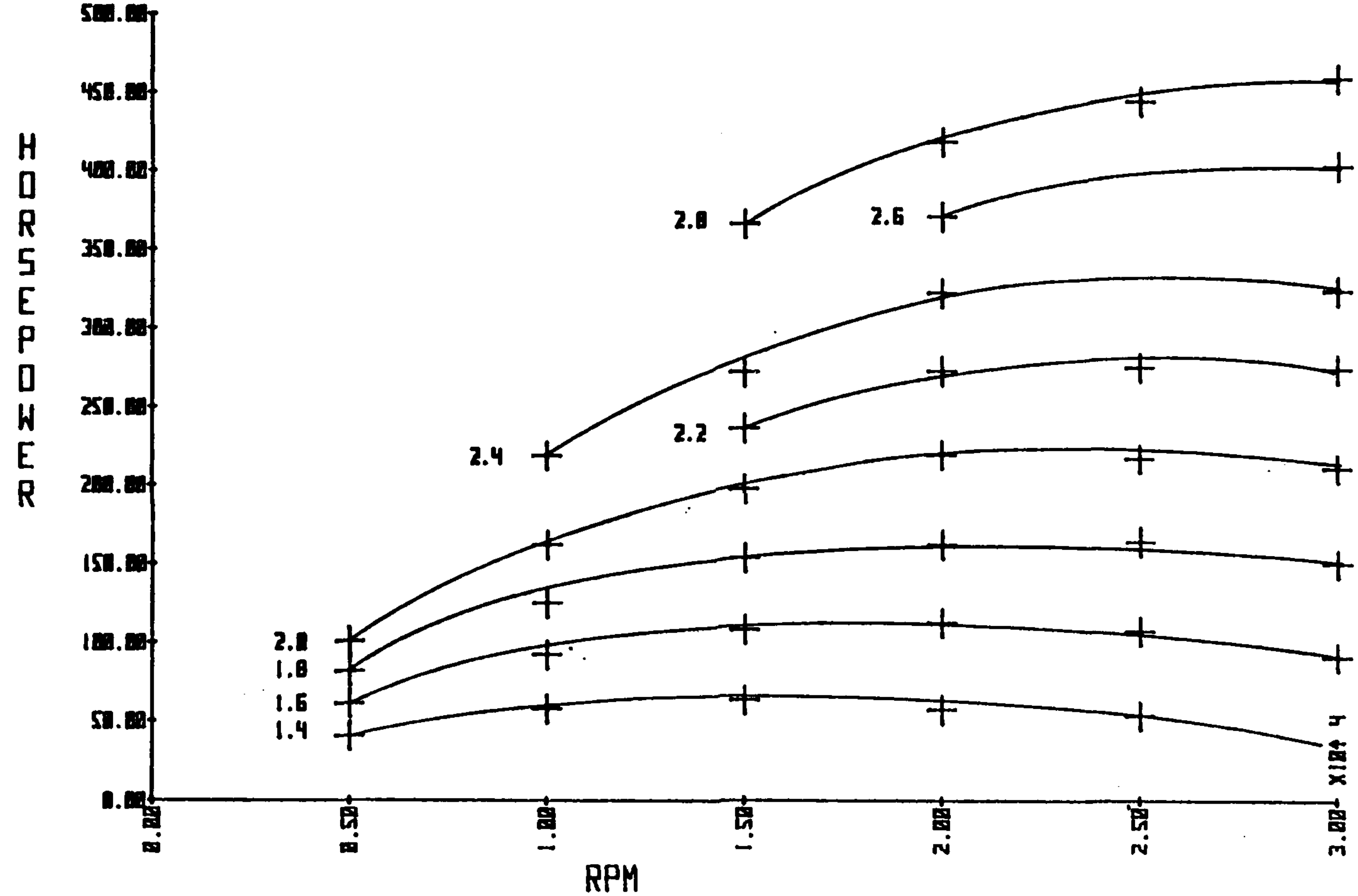


FIGURE 3: PREDICTED HORSEPOWER VS RPM AS A FUNCTION OF PRESSURE RATIO, AT TEMPERATURES TO AVOID CONDENSATION

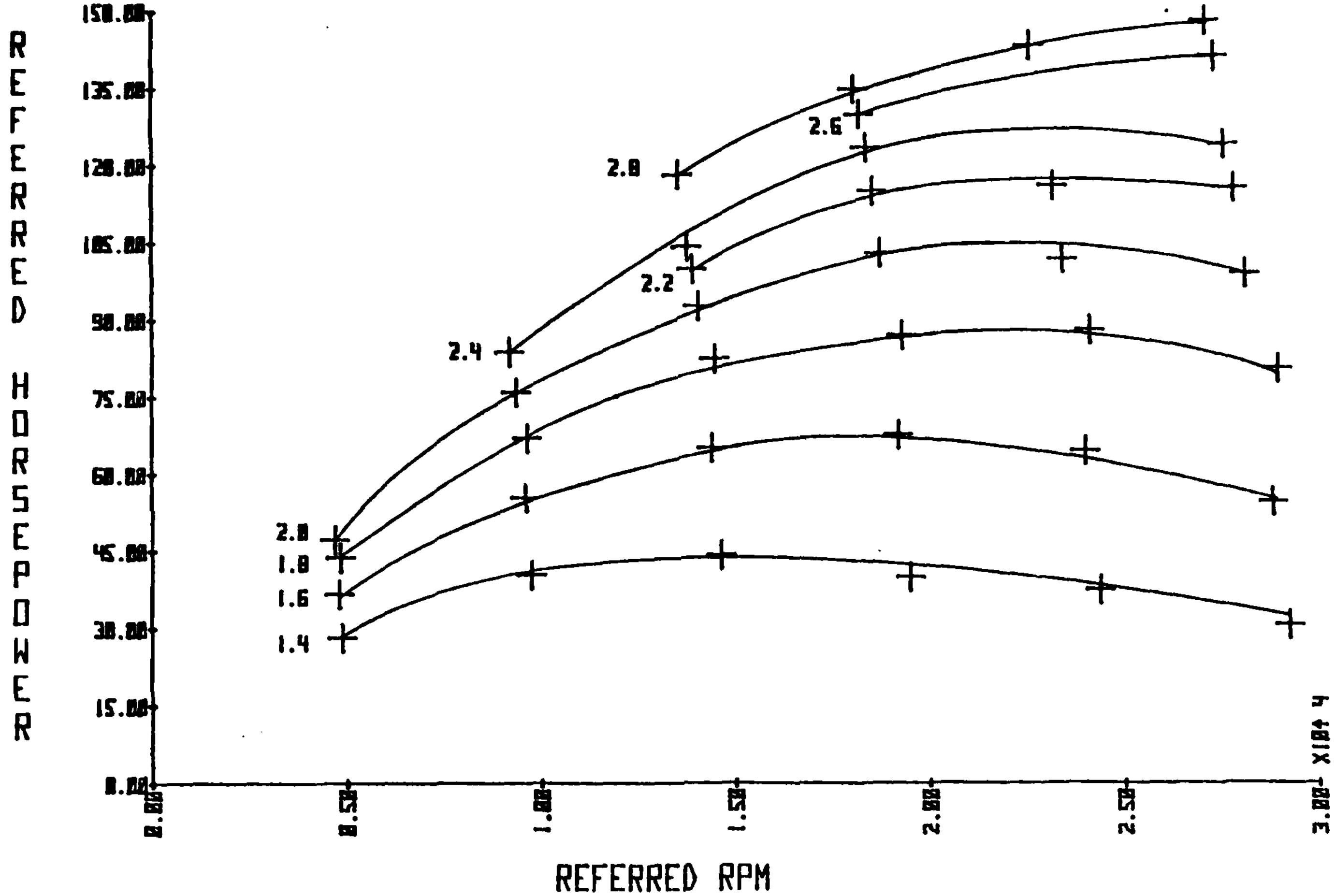


FIGURE 4: PREDICTED REFERRED HORSEPOWER VS REFERRED RPM AS A FUNCTION OF PRESSURE RATIO

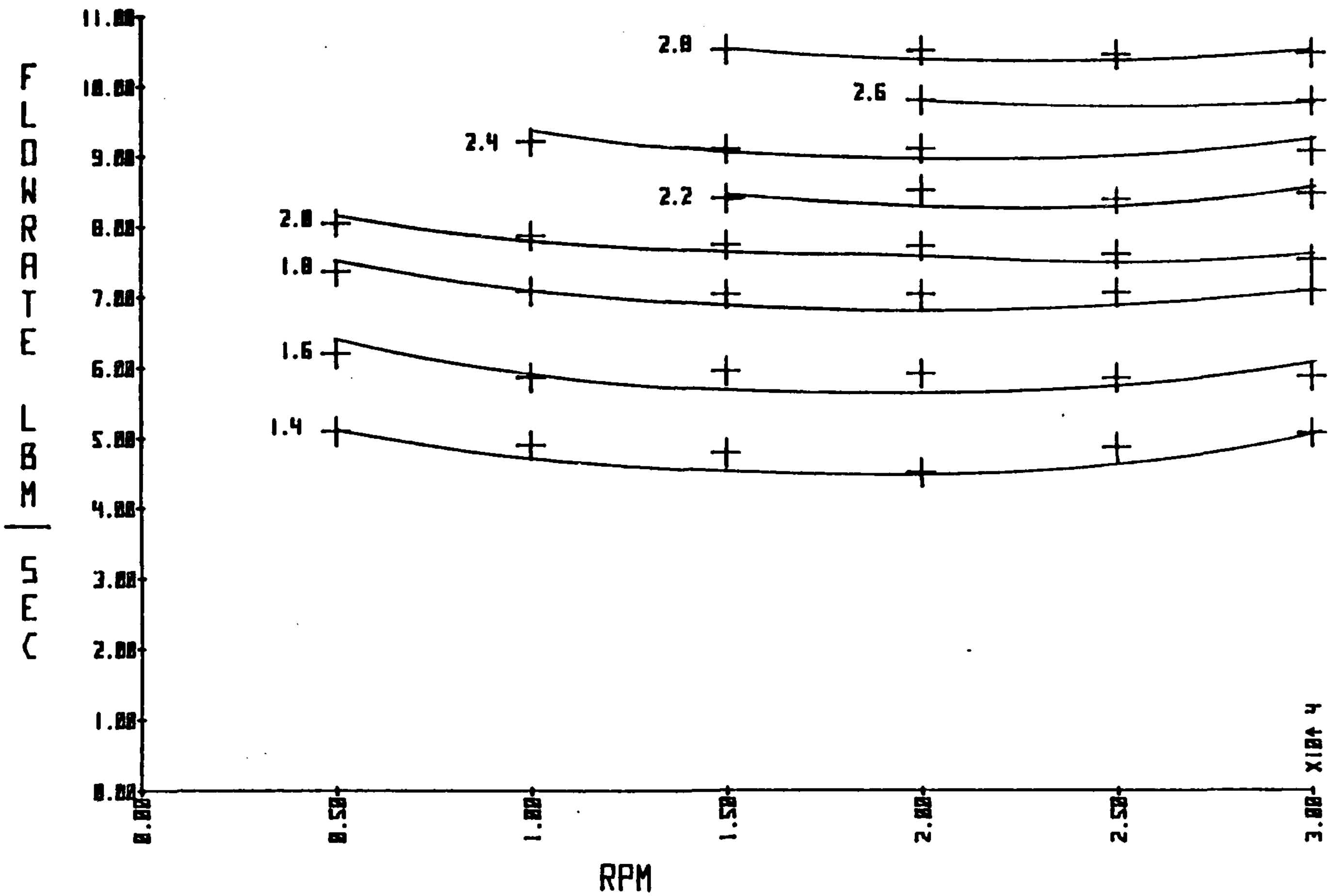


FIGURE 5: PREDICTED FLOWRATE VS RPM AS A FUNCTION OF PRESSURE RATIO AT TEMPERATURES TO AVOID CONDENSATION.

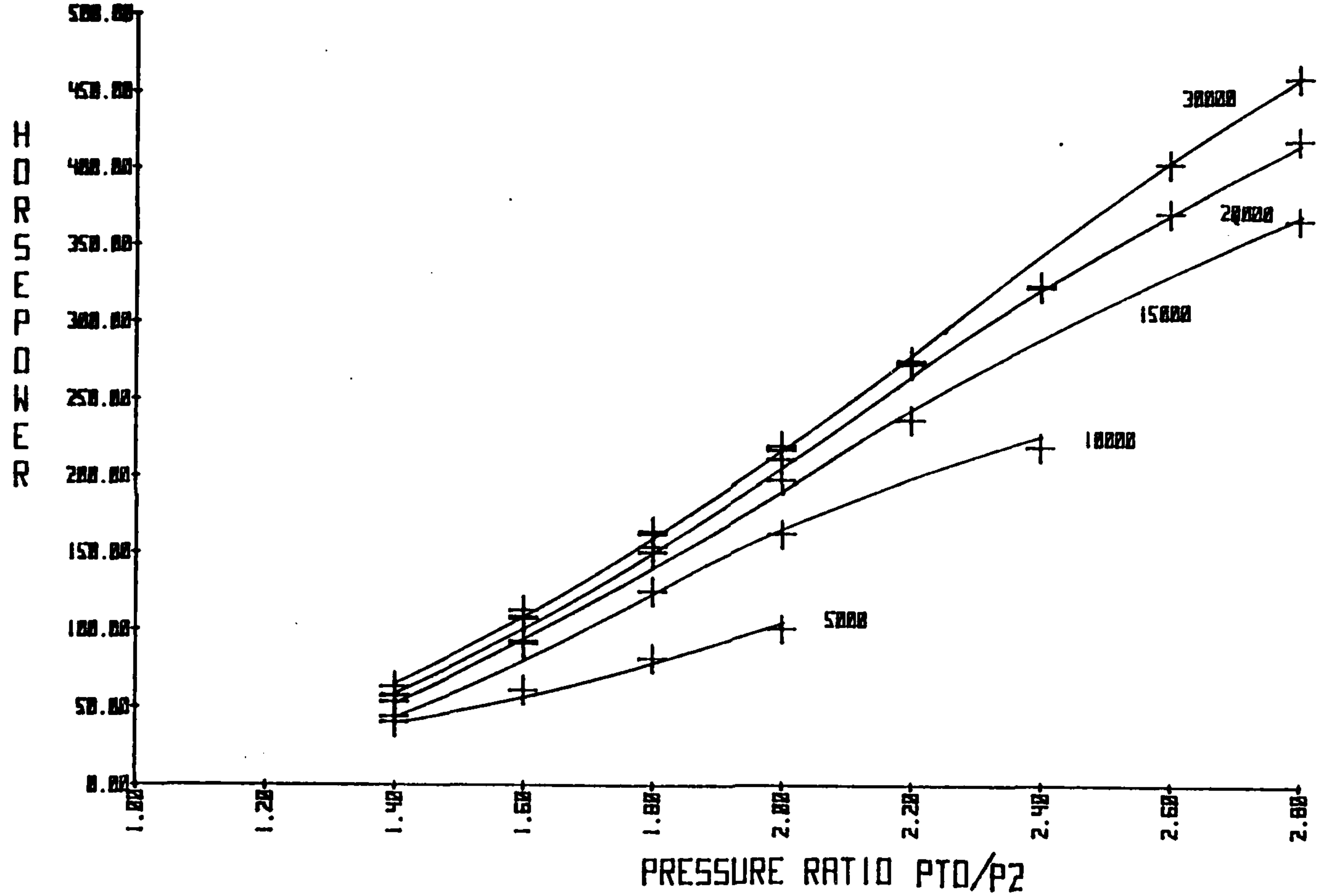


FIGURE 6: PREDICTED HORSEPOWER VS PRESSURE RATIO AS A FUNCTION OF RPM, AT TEMPERATURES TO AVOID CONDENSATION

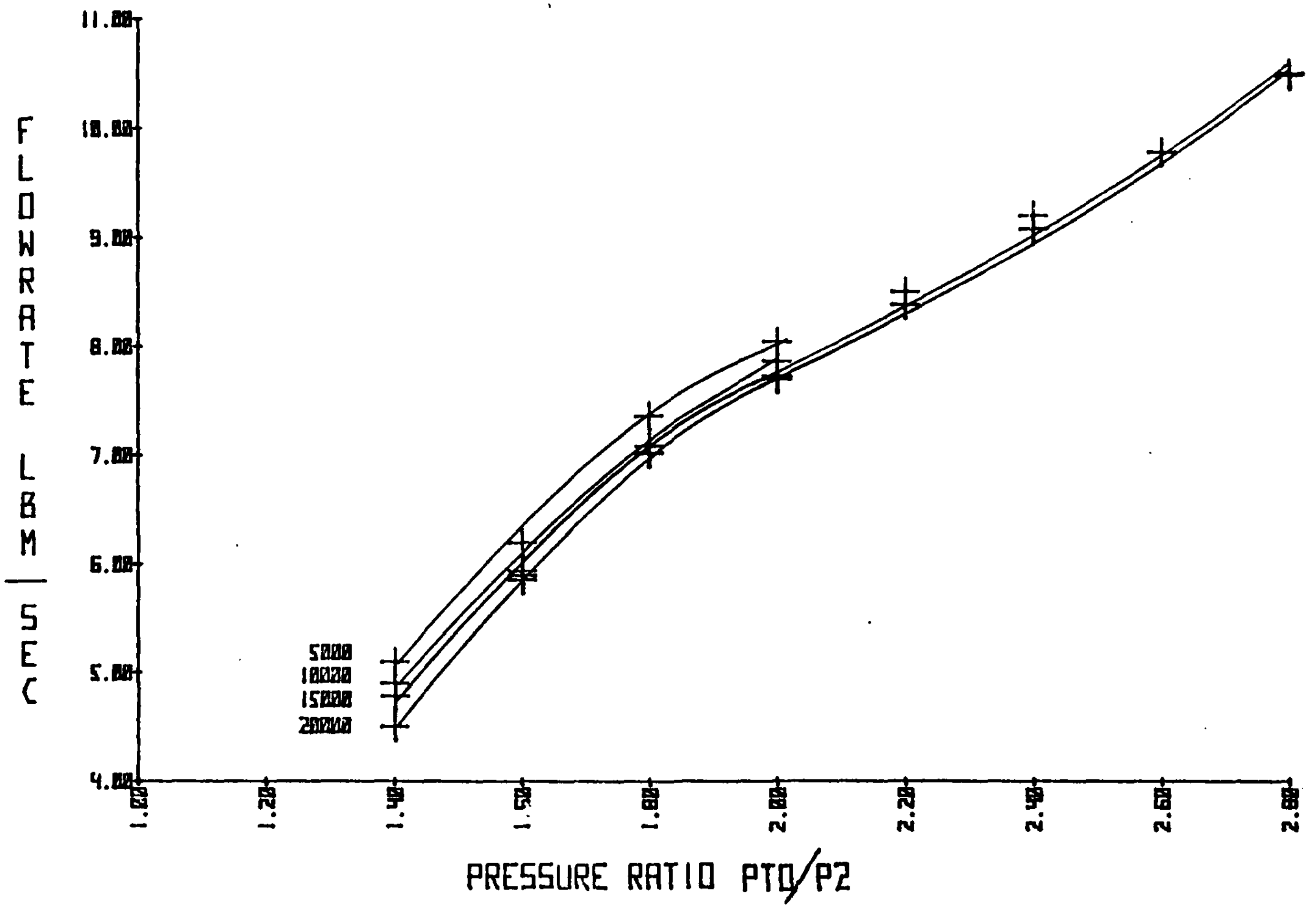


FIGURE 7: PREDICTED FLOW RATE VS PRESSURE RATIO AS A FUNCTION OF RPM AT TEMPERATURES TO AVOID CONDENSATION.

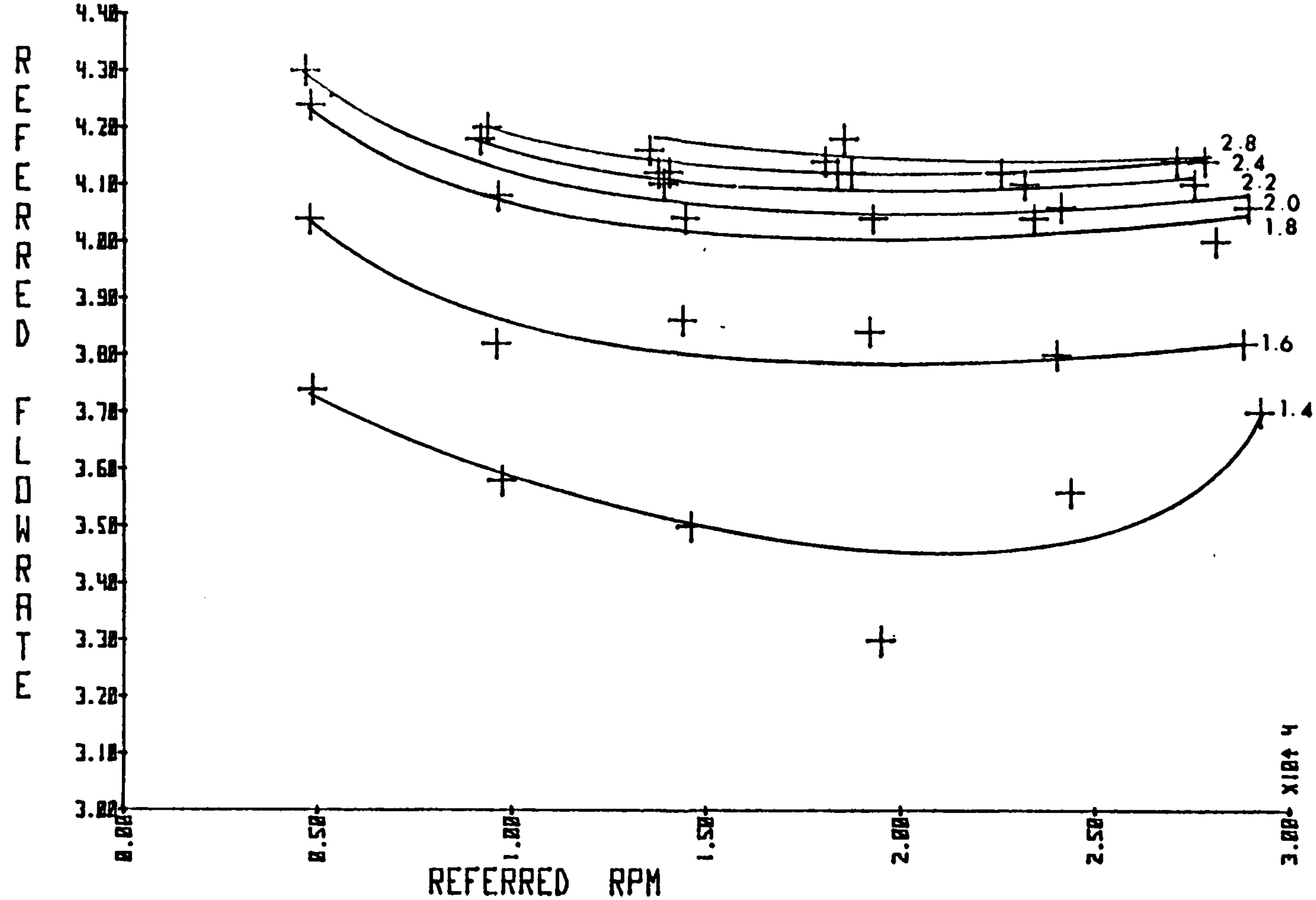


FIGURE 8: PREDICTED REFERRED FLOWRATE VS REFERRED RPM AS A FUNCTION OF PRESSURE RATIO

APPENDIX: A

DESCRIPTION OF THE COMPUTER PROGRAM

A-1. INTRODUCTION

To enable the program to run on the laboratory computer, the program was divided into 4 parts; a main program and 3 segments. A detailed discussion of program segmentation on the HP-1000 computer series is contained in Appendix C. In the description which follows, the program is treated as if it were one large program with many subroutines.

The description follows the individual steps from start to finish in the analysis. A program flowchart is given in Figure A-1 and the FORTRAN symbols used in the program are listed in Tables A-I to A-IX.

A-2. DESCRIPTION

A-2.1 Input Data

There are 4 basic categories of input data; turbine geometry, operating conditions, special data and program control parameters. Since there was no card reader input device on the computer, all data were entered using either data or specification statements. Explanations of the turbine geometry, operating conditions, special data and program control parameters are found in Table A-I through A-V. The nomenclature for the blading is given in Figure A-2.

A-2.2 Initial Geometric Calculations

The first calculation performed is to establish the 5 streamline locations at the stator inlet (station 0). The streamlines are initially positioned such that there are equal areas (25% of the total flow area) between them. Next, blade heights of the stator and rotor are calculated using the hub and tip radii of each blade. Blade spacings for the stator and rotor are computed at 3 streamlines; hub, mean and tip. The blade spacing on the mean streamline for the stator is given by

$$S = \frac{2\pi}{Z_s} Rm \tag{A-1}$$

where S = Blade spacing

Z_s = Number of stator blades

Rm = Mean stator radius

A-2.3 Calculation of Gas Outlet Angles

Subroutine VAVRA calculates gas outlet angles for both stator and rotor. The method is that of M.H. Vavra [Ref. 1]. The equation programmed in the subroutine is

$$\alpha = \cos^{-1}\left[\frac{a}{S} + 4\frac{t_e}{S}\left(1 - \frac{\cos^{-1}\left(\frac{a}{S}\right)}{90}\right)\right] \tag{A-2}$$

where α = Gas outlet angle

a = Throat opening

S = Blade spacing

t_e = Projected trailing edge thickness

This method is much simpler than that used by Macchi since

there is no variation in outlet angle with Mach number (for sub-sonic conditions). Therefore, once calculated, the stator and rotor exit angles remain unchanged. Subroutine VAVRA computes exit angles for the hub, mean and tip streamlines. The outlet angles at streamlines two and four are computed later in the subroutines STATR and ROTO2.

Before printing the input data, the program calculates the mean throat opening for the stator and for the rotor. The ten equally spaced radii and corresponding throat openings (part of the input geometry) are fitted with a fourth order Chebyschev polynomial. A throat opening corresponding to the mean radius is thus obtained. In the present application of the program to the drive turbine, the mean throat opening was obtained from the design drawing of the blading shown in Figure 2. It was assumed that the throat opening varied linearly with radial position and hence the throat openings at other radii could be calculated. The resulting throat openings are shown in the computer output under the heading of "Input Prints". The design values of the stator and rotor throat areas were obtained from the original design notes of M.H. Vavra.

A-2.4 Calculation of the Flow Rate

Subroutine CHAN is called to calculate the mass flow rate entering the stator. The equations used are as follows:

$$T = \frac{T_{TO}}{1 + \frac{\gamma - 1}{2} M_0^2} \tag{A-3}$$

$$V = \sqrt{g_c \gamma R T} \tag{A-4}$$

$$P = \frac{P_{TO}}{1 + \frac{\gamma - 1}{2} M_0^2} \tag{A-5}$$

$$\rho = P / RT \tag{A-6}$$

$$A = \pi \left[R_{TIP}^2 - R_{HUB}^2 \right] \tag{A-7}$$

$$\dot{m} = \rho A V \tag{A-8}$$

$$\dot{m}_{REF} = \frac{\dot{m}}{P_{TO}} \sqrt{\frac{R T_{TO}}{g_c}} \tag{A-9}$$

$\dot{m}_{ref}$ is the reference (dimensionless) flowrate and is used to check overall continuity later in the program.

A-2.5 Solution of the Equation of Motion for the Stator

Subroutine STATR is called to solve the equation of motion for the stator outlet conditions. The equation of motion which is programmed is as follows:

$$\frac{d(\ln Y_1^2)}{dX_1} = -\cos^2\alpha_1 \left[-\left(K\, 2 r_m \frac{\delta R}{L^2}\right) - \left(\frac{4L^2 + (\delta r)^2}{4L^2}\right) \cdot \frac{dS_1^*}{dX_1} \right] - 2 \tan\alpha \frac{d\alpha_1}{dX_1} - \frac{2}{X_1} \sin^2\alpha_1 +$$

$$\frac{C_1 \cos^2\alpha_1}{Y_1^2 Va_{1m}^2} \frac{dH}{dX_1} - \left[\frac{C_1 H \cos^2\alpha_1}{Y_1 Va_{1m}^2} - \sin^2\alpha_1 \right] \frac{dS_1^*}{dX_1} \tag{A-10}$$

where $C_1 = 2g_c J$ (a constant to convert H, the enthalpy from $\frac{BTU}{LBM}$ TO $\frac{FT^2}{sec}$)

$$Y_1 = \frac{V_a(I)}{V_a(3)} = \frac{\text{Axial velocity at a streamline}}{\text{Axial velocity at mean streamline}}$$

$$X_1 = \frac{R(I)}{R_m} = \frac{\text{Streamline radius}}{\text{Mean streamline radius}}$$

$$\frac{dS^*}{dX_1} = \frac{d}{dX}\left[\ln\left[\frac{1 - \dfrac{Y_1^2 V_{a_m}^2}{C_1 H \cos^2\alpha_1}}{1 - \dfrac{Y_1^2 V_{a_m}^2}{C_1 H \cos^2\alpha(1-\xi)}}\right]\right]$$

ξ = Stator loss coefficient (which is initially assigned an estimated value)

The derivation of this form of the equation of motion is given in Appendix B. However, at this stage of the analysis, the streamline curvature is assumed to be zero. Therefore, the equation of motion becomes:

$$\frac{d(\ln Y_1^2)}{dX_1} = -2\tan\alpha_1 \frac{d\alpha_1}{dX_1} - \frac{2}{X_1}\sin^2\alpha_1 + \frac{C_1\cos^2\alpha_1}{Y_1^2 V_{a_{1m}}^2} \cdot \frac{dH}{dX_1} \div \left[1 - \frac{C_1 H\cos^2\alpha_1}{Y_1^2 V_{a_{1m}}^2}\right]\frac{dS^*}{dX_1} \qquad \text{(A-11)}$$

The equation of motion is solved when the value of Y_1 at each streamline satisfies the equation. The solution is to first put the equation in the form:

$$\frac{d(\ln Y_1^2)}{dX_1} = I(X) \qquad \text{(A-12)}$$

where I(X) consists of the right hand side of equation (A-11). Integrating equation (A-12) yields;

$$\ln Y_1^2 = \int_{x_0}^{x} I(x)\, dX_1 + \ln c^2 \tag{A-13}$$

where $\ln c^2$ is the constant of integration when $x = 1$ and $Y_1 = 1$. With these boundary conditions Eq. (A-13) gives

$$\ln c^2 = -\int_{x_0}^{1} I(x)\, dX_1 \tag{A-14}$$

using Eq. (A-14) in Eq. (A-13),

$$\ln Y_1^2 = \int_{X_0}^{X_1} I(x)\, dX_1 - \int_{X_0}^{1} I(x)\, dX_1 \tag{A-15}$$

which becomes

$$\ln Y_1^2 = \int_{1}^{X_1} I(x)\, dX_1 \tag{A-16}$$

Taking the inverse natural log and the square root of both sides

$$Y_1 = e^{\frac{1}{2}\int_{1}^{x} I(x)\, dX_1} \tag{A-17}$$

Equation (A-17) is the form of the equation of motion solved in subroutine STATR. Solution of the equation gives five values of Y_1 and thus the value of the axial velocity at each of the five streamlines. Initially, the value of Y_1 is taken to be 1 and the value of $\frac{ds^*}{dx_1}$ is taken to be zero. In succeeding iterations, the calculated value of Y_1 is used to obtain a new value of $\frac{ds^*}{dx_1}$, and so on.

After calculating five values of Y_1, the stator exit conditions are calculated at each streamline from the geometry of the velocity diagram. The convention for positive

and negative angles and velocities is defined in Figure A-3. The required relations are the following:

$$V_{a_1} = V_{a_1}(3) \cdot Y_1 \qquad \text{(A-18)}$$

$$V_{u_1} = V_{a_1} \cdot \mathrm{TAN}\, \alpha_1 \qquad \text{(A-19)}$$

$$V_1 = V_{a_1} / \cos \alpha_1 \qquad \text{(A-20)}$$

$$V_{R_1} = - V_{a_1} \left[\Delta R / 2L \right] \qquad \text{(A-21)}$$

where L is the axial distance between stations and ΔR is the change in radial position of the streamline. V_{r_1}, the radial component of velocity, is taken to be zero at this stage in the calculation.

$$V_1 = \sqrt{V_1^2 + V_R^2} \qquad \text{(A-22)}$$

$$T_1 = T_{TO} - \frac{V_1^2}{2 g_c J C_p} \qquad \text{(A-23)}$$

$$T_{1,s} = T_{TO} - \left[\frac{T_{TO} - T_1}{1 - \xi_s} \right] \qquad \text{(A-24)}$$

$$P.R. = P_1 / P_{TO} \qquad \text{(A-25)}$$

$$P_1 = P_{TO} \left[\frac{T_{1,s}}{T_{TO}} \right]^{\frac{\gamma}{\gamma - 1}} \qquad \text{(A-26)}$$

$$M_1 = V_1 / \sqrt{\gamma g_c R T} \qquad \text{(A-27)}$$

After the above quantities have been calculated at each streamline, subroutine STATR returns to the main program.

A-2.6 Calculation of the Stator Loss Coefficients

The calculation of the stator loss coefficients at each streamline is accomplished by subroutine ALOS1.

The method of solution to obtain these loss coefficients is that formulated by Traupel [Ref. 7]. In Traupel's method, the value of the total loss coefficient is given by

$$\xi_{total} = \xi_{profile} + \xi_{wall} + \xi_{remaining} \quad \text{(A-28)}$$

The calculation of ξ_{total} requires 9 subroutines. Figure A-4 describes the connection between the subroutines and subroutine ALOS1.

The first step is to obtain the value of the total profile loss coefficient, ξ_p. ξ_p is defined by Traupel to be

$$\xi_p = \xi_{po} \chi_m \chi_\delta + \xi_m + \xi_f \quad \text{(A-29)}$$

where ξ_{po} = initial value of the profile loss coefficient

x_m = mach number correction factor

x_δ = trailing edge thickness correction factor

ξ_m = loss coefficient due to mixing losses and separation losses

ξ_f = loss coefficient due to fan losses

The total profile loss coefficient is calculated in the following manner. First, data for initial profile loss (ξ_{po}) as a function of gas outlet angle (α_1) for various values of gas inlet angle (α_0) is read from an array (Fig. A-5).

This is done by subroutine TRAU1 and functions XPO and YC. The values of ξ_{po} are contained in two arrays XPO1 (5, 8) and XPO2 (6, 8). This is because the data shown plotted in Fig. A-5 has been divided into two sets. One set is for values of α_1 between 40° and 80°. The other is for values of α_1 between 80° and 170°. The FORTRAN symbols for the two ranges of values of α_1 are ALFO1(I) and ALFO2(I) respectively. The FORTRAN symbol for the gas inlet angle is ALF1 (J) once the data pints selected from the plot are entered, fifth and sixth degree polynomials respectively are fitted through the data points. The value of ξ_{po} can then be determined for given values of α_1 and α_0.

The mach number correction, X_m is obtained from Fig. A-5. Subroutine CSIM calculates the value of X_m using straight line approximations of the plot.

Subroutine CID calculates the remaining terms in the expression for ξ_p. These are X_s, ξ_m, ξ_f. They are obtained from the data in Fig. A-6 using the linear interpolation. The abscissa of the curves for X_s and ξ_m is either f or 1-f where f is defined as

$$f = 1 - \frac{\delta}{t \sin \alpha_1} \qquad \text{(A-30)}$$

where δ = normal trailing edge thickness.

t = blade spacing.

α_1 = gas outlet angle.

The loss coefficient due to wall friction, ξ_w, is calculated using

$$\xi_W \cong \xi_{PO} \cdot \chi_P \frac{t \sin\alpha}{\ell} \qquad \text{(A-31)}$$

where t - blade maximum thickness

ℓ = blade height

This equation is programmed in subroutine CSIW.

The value of ξ_R is obtained using subroutine CSIR. ξ_R is defined by Traupel to be an all-inclusive loss coefficient which accounts for any remaining losses not previously defined. It is written as

$$\xi_R = \chi_L \, \xi_{RO} \qquad \text{(A-32)}$$

ξ_{RO} is an initial value of ξ_R which depends on the value of ϕ, where ϕ is given by

$$\phi = \frac{V_1 \sin\alpha_1}{U} \qquad \text{(A-33)}$$

in which v_1 = true velocity of gas

v = blade speed

A plot of ξ_{RO} vs ϕ is shown in Fig. A-7. The correction X_L is a function of s/ℓ where

s = chord length

ℓ = blade height

and is obtained using the data in the lower half of Fig. A-7.

The total stator loss coefficient is computed for 3 streamlines; those at the hub, mean and tip.

The loss coefficients at streamlines 2 and 4 are obtained by linear interpolation.

A refinement to the stator loss coefficient may be applied depending on the input value of one program control parameter. The following 3 variations of ξ_s are available:

$$\xi_s = \frac{\left[\dfrac{1+\xi_0}{1+\xi_0 \dfrac{P}{P_{T0}}}\right]^{\frac{\gamma-1}{\gamma}} - 1}{\left[\dfrac{1}{\dfrac{P}{P_{T0}}}\right]^{\frac{\gamma-1}{\gamma}} - 1} \tag{A-34}$$

$$\xi_s = \xi_0 \tag{A-35}$$

and

$$\xi_s = \frac{\left[\dfrac{1+\xi_0}{1+\xi_0 \beta^*}\right]^{\frac{\gamma-1}{\gamma}} - 1}{\left[\dfrac{1}{\beta^*}\right]^{\frac{\gamma-1}{\gamma}} - 1} \tag{A-36}$$

where ξ_0 = loss coefficient calculated using the method of Traupel

$$\beta^* = \left[1 + \frac{\gamma-1}{2}(.8)^2\right]^{\frac{\gamma-1}{\gamma}} \tag{A-37}$$

The values of the program control paramenter required to select between options are given in Table A-V.

Before returning to the main program, subroutine ALOS1 calculates a value of ξ^* which is a blockage factor to be used in the equation of continuity. There are three ways to define ξ^*; they are as follows:

$$\xi^* = \xi_o \tag{A-38}$$

$$\xi^* = \frac{1}{2}\xi_o \tag{A-39}$$

$$\xi^* = \xi_p \tag{A-40}$$

A-2.7 <u>Solution of the Continuity Equation After Returning to the Main Program</u>

The overall continuity at the stator exit is checked. Subroutine FLOWR performs this task. The flow chart for FLOWR is given in Fig. A-8. In FLOWR the mass flow rate required by continuity is checked against the calculated mass flow rate. If the calculated flow rate does not agree with that required by continuity, adjustments are made to the axial velocity and/or the inlet Mach number, as will be explained.

The mass flow required by continuity is

$$\dot{m}_{RE\dot{Q}D} = \frac{\dot{m}_{REF}}{Z_s \cdot A_m R_m} \tag{A-41}$$

where $\dot{m}_{REF}$ = reference mass flow rate as computed in subroutine CHAN

Z_s = # of stator blades

A_m = mean stator throat opening

R_m = mean stator radius

The mass flow rate at each streamline computed in this subroutine is

$$\dot{m}_{ACT} = \left[\frac{P_{TE}}{P_{TO}}\right] \sqrt{\frac{T_{TE}}{T_{TO}}} \left[\frac{A(I)}{A(3)}\right] Z \,\Phi \tag{A-42}$$

where Z is an area reduction coefficient defined by

$$Z = \frac{H^{***} - 1}{H^{***} - 1 + \xi^{*}} \tag{A-43}$$

Z gives the percentage of flow area between the blades overwhich it is permissable to assume a uniform velocity. The boundary layer on both sides of the flow limits the available flow area and the backage facotr, Z. accounts for this. Equation A-43, Z is seen to be a function of the energy parameter H^{***} and ξ^*. ξ^* is the value of the loss coefficient returned from subroutine ALOS1. The energy parameter is defined as

$$H^{***} = \frac{\delta 3}{\delta 1} = \frac{\text{Energy thickness}}{\text{Displacement thickness}} \qquad \text{(A-44)}$$

H*** can be written as

$$H^{***} = \frac{\left[\frac{1}{X_E - 1} + \frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^2}{7m+1} + \frac{X_E^3}{9m+1} + \frac{X_E^4}{11m+1}\right]}{\left[\frac{1}{X_E - 1} + \frac{1}{m+1} + \frac{X_E}{3m+1} + \frac{X_E^2}{5m+1} + \frac{X_E^3}{7m+1} + \frac{X_E^4}{9m+1}\right]} \qquad \text{(A-45)}$$

where:

$$m = .15$$

$$X_E = 1 - \left(\frac{P}{P_{TO}}\right)^{\frac{\gamma - 1}{\gamma}} \qquad \text{for unchoked flow}$$

$$X_E = 1 - [P_{CRIT}]^{\frac{\gamma - 1}{\gamma}} \qquad \text{for choked flow}$$

and

$$P_{CRIT} = \left[\frac{2}{\gamma + 1}\right]^{\frac{\gamma}{\gamma - 1}}$$

The derivation of Z and H*** os given in Appendix B.

The expression for Φ, the flow function, for unchoked flow is

$$\Phi = \sqrt{\left(\frac{2\gamma}{\gamma-1}\right)\left(\frac{P}{P_{TO}}\right)^{\frac{2}{\gamma}} - \left(\frac{P}{P_{TO}}\right)^{\frac{\gamma+1}{\gamma}}} \qquad \text{(A-46)}$$

and for choked flow is

$$\Phi = \left[\frac{2}{\gamma+1}\right]^{\frac{1}{\gamma-1}} \sqrt{\frac{2\gamma}{\gamma+1}} \qquad \text{(A-47)}$$

After calculating for each streamline, the flow rate is integrated from hub to tip and the resulting value is compared with $\dot{m}_{reqd}$. If the two values of flow rate agree to within a specified tolerance (see Table A-IV) continuity is considered to be satisfied. Then, after calculating the total percentage of mass flow between adjacent streamlines, subroutine FLOWR returns to the main program.

If the flow rates are not within tolerance the program checks to see if the actual mass flow is to high. If it is to high, the value of the axial velocity is lowered proportionally to the difference between the actual and required flow rates.

If the actual flow rate is too low, the procedure is more complicated. First, the flow is checked to determine whether choking has occurred. Streamlines one and five are checked. If the flow is in fact choked at those streamlines, the inlet Mach number is lowered and the program loops back to recompute the reference mass flow rate and repeat the complete procedure.

If the flow is not choked, the axial velocity is raised proportionally to the difference between actual and required flow rates and subroutine FLOWR returns to the main program.

A-2.8 Calculation of the Rotor Inlet Conditions

Continuity having been satisfied through the stator, the rotor relative inlet conditions are calculated. In subroutine ROTO1, the following expressions are used:

$$U = \frac{\omega R}{12} \qquad \text{(A-48)}$$

$$U_2 = \frac{\omega}{12} \cdot \frac{R_{STATOR}}{R_{ROTOR}} \qquad \text{(A-49)}$$

$$W_{u_1} = V_{u_1} - U \qquad \text{(A-50)}$$

$$\beta_1 = \mathrm{TAN}^{-1}\left[\frac{W_{u_1}}{V_{a_1}}\right] \qquad \text{(A-51)}$$

$$W_1 = \frac{V_{a_1}}{\cos \beta_1} \qquad \text{(A-52)}$$

$$W_1 = \sqrt{V_{R_1}^2 + W_1^2} \qquad \text{(A-53)}$$

$$T_{TE} = \frac{(T_1 + W_1)^2}{2 g_c J c_p + \left(\frac{U_2^2 - U_1^2}{2 g_c J c_p}\right)} \qquad \text{(A-54)}$$

$$P_{TE} = P_1 \left[\frac{T_{TE}}{T_1}\right]^{\frac{\gamma}{\gamma - 1}} \qquad \text{(A-55)}$$

$$H_E = (T_{TE})(.24) \tag{A-56}$$

Where T_{TE}, P_{TE} and H_E are equivalent temperature, pressure and enthalpy respectively.

A-2.9 Calculation of the Rotor Exit Conditions

Calculation of the rotor exit properties follows the same procedure as was used to compute the stator exit properties. The process is outlined here with notable differences explained. Subroutine ROTO2 calculates the rotor exit properties. A flowchart of ROTO2 is given in Fig. A-9.

The first step in ROTO2 is to solve the equation of motion for each streamline. The equation of motion in terms of relative quantities is

$$\frac{d(\ln Y_2^2)}{dX_2^2} = -\cos^2\beta_2 \left[2K r_m \frac{\delta r}{L^2} - \frac{L^2 + \left(\frac{\Delta R}{2}\right)^2}{L^2} \cdot \frac{ds^*}{dX} \right] - 2\tan\beta_2 \frac{d\beta_2}{dX_2} - \frac{2}{X_2}\sin^2\beta_2 - \frac{4U_m \cos\beta_2 \sin\beta_2}{Y_2^2 Va_2^2}$$

$$- \frac{2U_m U_2 \cos^2\beta_2}{Y_2^2 Va_2^2} + \frac{C_1 \cos^2\beta_2}{Y_2^2 Va_2^2} \cdot \frac{dH_E}{dX_2} +$$

$$\left[1 - \frac{C_1 H_E \cos^2\beta_2}{Y_2^2 Va_2^2} \right] \cdot \frac{ds_2^*}{dX_2} \tag{A-57}$$

At this point in the calculation, streamline curvature is neglected. Hence, Eq. (A-57) reduces to

$$\frac{d(\ln Y_2^2)}{dX_2} = -2\,\mathrm{TAN}\,\beta_2 \frac{d\beta_2}{dX_2} - \frac{2}{X_2}\mathrm{SIN}^2\beta_2 -$$

$$\frac{4 U_m \cos\beta_2 \sin\beta_2}{Y_2 Va_2} - \frac{2 U_m U_2 \cos^2\beta_2}{Y_2^2 Va_2^2} +$$

$$\frac{C_1 \cos^2\beta_2}{Y_2^2 Va_2^2}\frac{dH_E}{dX_2} + \left[1 - \frac{C_1 H_E \cos^2\beta_2}{Y_2^2 Va_2^2}\right]\frac{dS_2}{dX_2} \qquad \text{(A-58)}$$

The derivation of Eq. (A-57) is contained in Appendix B. Equation (A-55) is similar in form to Eq. (A-10). Hence, the method of solution is identical to that employed by subroutine STATR. However, after solving the equation, the value of Y_2 at each streamline is examined to determine whether or not it falls into the range $.2<Y_2<2.0$. Values of Y_2 greater than 2.0 are set equal to 2.0 while those less than .2 are set equal to .2. Successive values of Y_2 at each streamline are compared, and when the values of successive iterations are within a specified tolerance (see Table A-IV), the iteration ends. The values of Y_2 are used to calculate the rotor exit conditions using the following equations:

$$Va_2 = Va_2(3)\,Y_2 \qquad \text{(A-59)}$$

$$W_2 = \frac{V_{a_2}}{\cos\beta_2} \tag{A-60}$$

$$W_{R_2} = \frac{(-V_{a_2})\cdot D\cdot CL}{2} \tag{A-61}$$

$$T_2 = T_{TE} - \frac{W_2^{\,2}}{2 g_c J c_p} \tag{A-62}$$

$$V_{u_2} = V_{a_2} \, \mathrm{TAN}\,\beta_2 \tag{A-63}$$

$$W_{u_2} = V_{u_2} + U \tag{A-64}$$

$$T_{2s} = T_{TE} - \frac{T_{TE} - T_2}{1 - \xi_R} \tag{A-65}$$

$$P_2 = P_{TE} \left[\frac{T_{2s}}{T_{TE}}\right]^{\frac{\gamma}{\gamma-1}} \tag{A-66}$$

Subroutine ROTO2, then returns to the main program.

After calculating the rotor outlet conditions, the rotor loss coefficients are computed. Subroutine ALOS2

calculates the rotor loss coefficients following the process used in subroutine ALOS1 for the stator losses. The principle exception is that a tip clearance loss is also calculated and added to the total loss coefficient. The tip clearance loss coefficient is obtained from subroutine ALEAK which uses a straight line approximation to the curve shown in Fig. A-10. Subroutine ALOS2 also computes values of ξ^* and one of the three refinements to ξ_R.

Subroutine FLOWR is called to check continuity at the rotor exit. If continuity is satisfied, the program continues. If not, the same procedure is followed as previously explained for the stator outlet (Fig. A-1).

A-2.10 Accounting for Streamline Curvature

All calculations to this point have neglected streamline curvature and assumed that the streamlines remain fixed through the stator and rotor (Fig. A-11). The radial shift in a streamline between stator inlet and rotor outlet can be written as

$$\Delta R = R_{\substack{\text{STATOR}\\ \text{INLET}}} - R_{\substack{\text{ROTOR}\\ \text{OUTLET}}} \qquad \text{(A-67)}$$

This is the net radial shift in a streamline between stations '0' (stator inlet) and '2' (rotor outlet). It is shown in Section 16.4 of Ref. [5] that the radial shift in a streamline between the stator and the rotor (station 1) can be written as

$$\delta R = R_{\substack{\text{STATOR}\\ \text{OUTLET}}} - \frac{1}{2}\left[R_{\substack{\text{STATOR}\\ \text{INLET}}} - R_{\substack{\text{ROTOR}\\ \text{OUTLET}}}\right] \tag{A-68}$$

The angle between the meridional velocity V_m and the axial velocity V_1 is λ. The radial velocity V_r can be expressed as

$$V_R = V_a \operatorname{TAN} \lambda \tag{A-69}$$

and from Fig. 16(1) of Ref.[5], it follows that

$$\operatorname{TAN} \lambda = \frac{-\Delta R}{2L} \tag{A-70}$$

Using Eq. (A-68) in Eq. (A-67),

$$V_R = -V_a \frac{\Delta R}{2L} \tag{A-71}$$

where $\frac{\Delta R}{2L}$ = Average streamline slope

Also, from using Eq. (A-68)

$$\cos \lambda = \frac{2L}{\sqrt{\Delta R^2 + (2L)^2}} \tag{A-72}$$

Rearranging;

$$\cos \lambda = \sqrt{\frac{L^2}{L^2 + \left(\frac{\Delta R}{2}\right)^2}} \tag{A-73}$$

The remaining term used in the calculation of streamline curvature (Section 16-4 of Ref. [5]) is

$$K \frac{\delta R}{L^2}$$

where K is the so called curvature factor. It usually has a value between 4 and 6 and in the program its value is taken to be 5. Having calculated $\cos\lambda$, ΔR and δR, the program repeats the solution process. However, the only quantity which is unchanged is the reference mass flow rate $\dot{m}_{ref}$. In subroutine STATR the equation of motion is solved, this time accounting for streamline curvature. The same is true in subroutine ROTO2.

The flow path of the program is identical to the section which did not account for streamline curvature. Next, the program computes an average pressure ratio at the rotor outlet using the expression

$$\frac{P_2}{P_{TO}} = \left(\frac{P_2}{P_{TO}}\right)_{\substack{\text{STREAMLINE}\\ 1}} + \frac{1}{4}\left[\left(\frac{P_2}{P_{TO}}\right)_{\substack{\text{S.L.}\\ 2}} \left(\frac{P_2}{P_{TO}}\right)_{\substack{\text{S.L.}\\ 3}} + \left(\frac{P_2}{P_{TO}}\right)_{\substack{\text{S.L.}\\ 4}} + \left(\frac{P_2}{P_{TO}}\right)_{\substack{\text{S.L.}\\ 5}}\right] \tag{A-74}$$

If this pressure ratio is within a specified tolerance to the actual pressure ratio (which is input data) the program

proceeds to the final stage of the calculations. If not, the inlet mach number is adjusted by an amount which depends on the difference between the calculated and specified pressure ratios. If the calculated pressure ratio is too high, the Mach number is lowered using

$$M_o = M_o - \frac{\text{Pressure Ratio Difference}}{18} \qquad \text{(A-75)}$$

If the computed pressure ratio is too low, the Mach number is raised using

$$M_o = M_o + \frac{\text{Pressure Ratio Difference}}{18} \qquad \text{(A-76)}$$

In both cases, the program loops back to subroutine CHAN and proceeds to compute a new reference mass flow rate based on the new value of the inlet Mach number. The entire process is then repeated until the pressure ratios agree within the specified tolerance.

A-2.11 Final Calculations

Stator and rotor outlet conditions not previously calculated are computed as follows:

$$\alpha_2 = \tan^{-1}\left[\frac{V_{u_2}}{V_{a_2}}\right] \qquad \text{(A-77)}$$

$$V_2 = \frac{V_{a_2}}{\cos \alpha_2} \qquad \text{(A-78)}$$

$$V_2 = \sqrt{V_2^2 + W_{R_2}^2} \tag{A-79}$$

$$\Delta h = \frac{U V_{u_1} - U_2 V_{u_2}}{g_c J} \tag{A-80}$$

$$T_{T_2} = T_{T0} - \frac{\Delta h}{C_p} \tag{A-81}$$

$$P_{T_2} = P_2 \left[\frac{T_{T_2}}{T_2}\right]^{\frac{\gamma}{\gamma-1}} \tag{A-82}$$

$$P_{T_1} = P_1 \left[\frac{T_{T0}}{T_1}\right]^{\frac{\gamma}{\gamma-1}} \tag{A-83}$$

$$T_{2_{is}} = T_{T0} \left[\frac{P_2}{P_{T0}}\right]^{\frac{\gamma-1}{\gamma}} \tag{A-84}$$

$$\text{ROTOR EXIT RELATIVE MACH \#} = \frac{W_2}{\sqrt{\gamma R g_c T_2}} \tag{A-85}$$

$$T_{T_{1s}} = T_{T0} \left[\frac{P_{T_2}}{P_{T0}} \right]^{\frac{\gamma-1}{\gamma}} \qquad \text{(A-86)}$$

$$\eta_{T-T} = \frac{T_{T0} - T_{T2}}{T_{T0} - T_{T1s}} \qquad \text{(A-87)}$$

$$\eta_{T-S} = \frac{T_{T0} - T_{T2}}{T_{T0} - T_{2_{1S}}} \qquad \text{(A-88)}$$

$$\text{Stator Blade Efficiency} = \frac{T_{T0} - T_1}{T_{T0} - T_{1,s}} \qquad \text{(A-89)}$$

$$\text{Rotor Blade Efficiency} = \frac{T_{TE} - T_2}{T_{T0} - T_{2_{1S}}} \qquad \text{(A-90)}$$

$$r^* = \frac{T_{1s} - T_{2_{1S}}}{T_{T0} - T_{2_{1S}}} \qquad \text{(A-91)}$$

$$\text{Head Coefficient} = \frac{2\, g_c\, J\, (T_{T0} - T_{2_{1S}})}{U^2} \qquad \text{(A-92)}$$

$$\text{Blade-Jet Ratio} = [\text{Head Coefficient}]^{-1} \qquad \text{(A-93)}$$

$$\text{Stator Exit Relative Mach \#} = \frac{W_1}{\sqrt{\gamma R g_c T_1}} \qquad \text{(A-94)}$$

The turbine horsepower is obtained by integration. The Δh term at each streamline is weighted by the percentage of mass flow at that streamline. The product is then integrated from hub to tip and result, $\Delta\bar{h}$, is used in the turbine horsepower equation

$$H.P. = \frac{\Delta\bar{h} \cdot J \cdot \dot{m}}{550} \tag{A-95}$$

The moment is calculated using

$$M = \frac{(H.P.)(550)}{\omega} \tag{A-96}$$

Referred horsepower, moment, mass flow and RPM are calculated using

$$H.P._{REF} = \frac{H.P.}{\theta\,\delta} \tag{A-97}$$

$$M_{REF} = \frac{M}{\delta} \tag{A-98}$$

$$\dot{m}_{REF} = \frac{\dot{m}\,\theta}{\delta} \tag{A-99}$$

$$RPM_{REF} = \frac{RPM}{\theta} \tag{A-100}$$

where

$$\Theta = \frac{T_{TO}}{518.4}$$

$$\delta = \frac{P_{TO}}{14.7}$$

The values of the total-static efficiency, total-total efficiency, total-static pressure ratio, total-total pressure ratio, head coefficient, blade/jet ratio, r* and inlet mach number are then averaged.

With all calculations completed, the results are printed under the heading "STATOR SOLUTION", "ROTOR SOLUTION", and "OVERALL TURBINE CHARACTERISTICS".

TABLE A-I

TURBINE GEOMETRIC INPUT DATA (STATOR)
(see Figure A-2; Dimensions in inches)

FORTRAN SYMBOL	DESCRIPTION
ZS	Number of blades
RS(1)	Hub radius at stator outlet
RS(3)	Mean radius at stator outlet
RS(5)	Tip radius at stator outlet
C	Blade chord (mean)
CI	Blade chord (hub)
CO	Blade chord (tip)
E	Blade curvature (mean)
EI	Blade curvature (hub)
EO	Blade curvature (tip)
T	Maximum blade thickness (mean)
TI	Maximum blade thickness (hub)
TO	Maximum blade thickness (tip)
TE	Projected T.E. thickness (mean)
TEI	Projected T.E. thickness (hub)
TEO	Projected T.E. thickness (tip)
TN	Normal T.E. thickness (mean)
TNI	Normal T.E. thickness (hub)
TNO	Normal T.E. thickness (tip)
A1(1-10)	Ten values of throat diameter at 10 equally spaced radii

FORTRAN SYMBOL	DESCRIPTION
AL	Blade camber line length (mean)
ALI	Blade camber line length (hub)
ALO	Blade camber line length (tip)
RC(1)	Hub radius at stator inlet
RC(3)	Mean radius at stator inlet
RC(5)	Tip radius at stator inlet

TABLE A-II

TURBINE GEOMETRIC INPUT DATA (ROTOR)
(see Figure A-2; Dimensions in inches)

FORTRAN SYMBOL	DESCRIPTION
ZR	Number of blades
RR(1)	Hub radius
RR(3)	Mean radius
RR(5)	Tip radius
CR	Blade chord (mean)
CIR	Blade chord (hub)
COR	Blade chord (tip)
ER	Blade curvature (mean)
EIR	Blade curvature (hub)
EOR	Blade curvature (tip)
TR	Maximum blade thickness (mean)
TIR	Maximum blade thickness (hub)
TOR	Maximum blade thickness (tip)
TER	Projected T.E. thickness (mean)
TEIR	Projected T.E. thickness (hub)
TEOR	Projected T.E. thickness (tip)
TNR	Normal T.E. thickness (mean)
TNIR	Normal T.E. thickness (hub)
TNOR	Normal T.E. thickness (tip)
TIPC	Tip clearance

FORTRAN SYMBOL	DESCRIPTION
A2(1-10)	10 values of throat diameter at 10 equally spaced radii
ALR	Blade camber line length (mean)
ALIR	Blade camber line length (hub)
ALOR	Blade camber line length (tip)
CV	Axial distance between stations
CK	Curvature Factor

TABLE A-III

TURBINE OPERATING CONDITIONS (INPUT DATA)

FORTRAN SYMBOL	DESCRIPTION
AMC	Assumed inlet Mach number
AMS	Assumed stator exeit Mach number (absolute)
AMR	Assumed stator exit Mach number (relative)
PTO	Total inlet pressure (P_{TO})
TTO	Total inlet temperature (T_{TO})
PR	Total-static pressure ratio
RPM	Operating speed (RPM)
VA1(3)	Assumed axial velocity in stator
VA2(3)	Assumed axial velocity in rotor

TABLE A-IV

SPECIAL INPUT DATA

FORTRAN SYMBOL	DESCRIPTION
TOL 1	Tolerance for convergence of equation of continuity
TOL 2	Tolerance for between-S.L. continuity (not used)
TOL 3	Tolerance in pressure ratio convergence
TOL 4	Tolerance in equation of motion convergence

TABLE A-V

PROGRAM CONTROL PARAMETERS

FORTRAN SYMBOL	POSSIBLE VALUE	EFFECT/MEANING
IND	1	Prints results in subroutines STATR, FLOWR, ROTO2
	1	No printing in the above
ICL	1	Rotor is shrouded
	1	Rotor not shrouded
ICOZ	1	$\xi = \xi_0$
	6	$\xi = \xi$ (Y Pressure Ratio)
	8	$\xi = \xi_{M=.8}$
ICON	1	$\xi = .5\xi_{TOTAL}$
	2	$\xi = \xi_{PROFILE}$
	3	$\xi = \xi_{TOTAL}$

TABLE A-VI

FORTRAN SYMBOLS IN THE MAIN PROGRAM

FORTRAN SYMBOLS	DESCRIPTION
BESP	$\beta^* = [1 + \frac{\gamma-1}{2} \cdot (.8)^2]^{\frac{\gamma-1}{\gamma}}$
OI	Stator throat opening (hub)
OO	Stator throat opening (tip)
OIR	Rotor throat opening (hub)
OOR	Rotor throat opening (tip)
O	Stator throat opening (mean)
OR	Rotor throat opening (mean)
ANG2I	Stator gas outlet angle (hub)
ANG2O	Stator gas outlet angle (tip)
BETAI	Rotor gas outlet angle (hub)
BETAZ	Rotor gas outlet angle (tip)
G	Grav. constant, 32.174 $\frac{FT.LBM}{LBF.sec^2}$
CJ	778.16 FT.LBF/BTU
EXP1	$^{\gamma}/_{\gamma} - 1$
EXP2	$^{\gamma-1}/_{\gamma}$
ERRE	Gas constant, 53.3459 $\frac{FT.LBF}{LBM.oR}$
EMME	Molecular mass, 28.970 LBM/LB MOLE
GAM	γ, Ratio of specific heats
ETAT	Total-total efficiency
ETAI	Total-static efficiency
ETAS	Stator blade efficiency

FORTRAN SYMBOL	DESCRIPTION
ETAR	Rotor blade efficiency
RSTAR	Theoretical degree of reaction
ALOS	Head coefficient
BLAJE	Blade/jet ratio
DR1	Radial shift of steamlines
AMW1	Stator exit relative Mach Number
AMS1	Stator exit absolute Mach Number
AMV2	Rotor exit absolute Mach Number
AMR2	Rotor exit relative Mach Number
DELH	Δ
HP	Horsepower
AMOM	Moment
THETA	θ
DELTA	δ
HP1	Referred H.P.
AMOM1	Referred moment
RPM1	Referred RPM
WLBM1	Referred mass flow rate
ETA5	Average total-static efficiency
BETA6	Average total-total pressure ratio
ETA6	Average total-total efficiency
AKIS5	Average head coefficient
RSTAR5	Average theoretical degree of reaction

TABLE A-VII

FORTRAN SYMBOLS IN SUBROUTINE CHAN

FORTRAN SYMBOLS	DESCRIPTION
TTO	T_{TO}, total temp. at station Ø
AMC	Inlet Mach number
PTO	P_{TO}, total pressure at station Ø
RC (I)	Streamline radii at station Ø
WLBM	$\dot{M}$, required mass flow, ρAV
TC	Static temperature
VC	Velocity
PC	Static pressure
RHO	ρ, density of air
WCHAN	$\dot{M}_{REF}$, reference mass flow
WPERO	% of $\dot{M}$ at each streamline

TABLE A-VIII

FORTRAN SYMBOLS IN SUBROUTINE STATR

FORTRAN SYMBOL	DESCRIPTION
ALFA1	Stator gas outlet angle
X	Ratio of streamline radius/ mean radius
AMS	Mach Number at station 1
T	Static temperature
P	Static pressure
V1	Absolute velocity
VA1	Axial velocity
Y	Ratio of axial velocity to mean axial velocity
S	Entropy
DSDX	Entropy gradient between streamlines
VU1	Tangential velocity
PRAT	$(\text{Total-static pressure ratio})^{-1}$
T1IS	T_{1IS}
DALF	$\frac{d\alpha}{dx}$
RSF	Mean stator radius
DELR	$R_{\text{Stator in}} - R_{\text{rotor out}}$
ZETAPS	$\S_p$
ZETAS	$\S_s$
VR1	Radial velocity

TABLE A-IX

FORTRAN SYMBOLS IN SUBROUTINE TRAU2

FORTRAN SYMBOL	DESCRIPTION
CSIP	X_p, correction to
R	$\S_{po}$, initial profile loss coefficient
ANG1	Gas outlet angle
ANG2	Gas inlet angle
R1	X_m, Mach No. correction
R3	$\S_R$, remaining loss coefficient
R2	$\S_W$, loss coefficient due to wall friction
RPRO	$\S_p$, total profile loss coefficient
CL	Rotor tip clearance
YCL	Tip clearance loss coefficient
RTOT	Total loss coefficient
T	Blade spacing
DEZ	Normal trailing edge thickness
HM	Blade height
CSID	X_δ, trailing edge thickness correction factor
PSID	$\S_f$, loss coefficient due to fan losses
PSIF	$\S_m$, loss coefficient due to mixing and separation
UM	Tip speed

TABLE A-X

FORTRAN SYMBOLS IN SUBROUTINE FLOWR

FORTRAN SYMBOL	DESCRIPTION
PRATCR	Critical pressure ratio
PHICR	Φ_{CRIT}, critical flow function
HSTAR	H***, energy parameter
XI	Ξ, area reduction coefficient
PHI	Φ, flow function (unchoked flow)
ARAT	Streamline throat DIA/mean throat DIA
SUM 1,2,3,4	Successive values of the flow integral
AS	Mean stator throat diameter
AR	Mean rotor throat diameter
WREQ	$\dot{M}$ required to satisfy continuity
WSUM	$\dot{M}$ calculated
WPER	% of $\dot{M}$ at each streamline

TABLE A-XI

FORTRAN SYMBOLS IN SUBROUTINE ROTO1

FORTRAN SYMBOL	DESCRIPTION
OMEG	ω, wheel speed (RAD/sec)
U	$\omega \cdot R_{stator\ mean}$
U2	$\omega \cdot \frac{R_{rotor\ mean}}{R_{stator\ mean}}$
WU1	W_{u_1} see figure A-3
BETA1	β_1, see figure A-3
W1	W_1, see figure A-3
TTE	Equivalent temperature
PTE	Equivalent pressure
HE	Equivalent enthalpy
ZETAR	ζ_R rotor loss coefficient
ZETAPR	ζ_p, rotor profile loss coefficient
DHEDX	Enthalpy gradient between streamlines
DSDX	Entropy gradient between streamlines

TABLE A-XII

FORTRAN SYMBOLS IN SUBROUTINE ROTO2

FORTRAN SYMBOL	DESCRIPTION
BETA2	β_2, see figure A-3
DBETDX	$\frac{d\beta}{dx}$ between adjacent streamlines
VA2	V_{a_2}, axial velocity
W2	W_2, see figure A-3
CL	Axial distance between stations
WR2	Radial component of velocity
WU2	Wu_2 , see figure A-3
VU2	Vu_2, see figure A-3
AMR	Relative Mach No. at rotor exit
T2	T_2
T2S	T_{2s}
P2	P_2
PRAT2	$[\text{Total-static pressure ratio}]^{-1}$

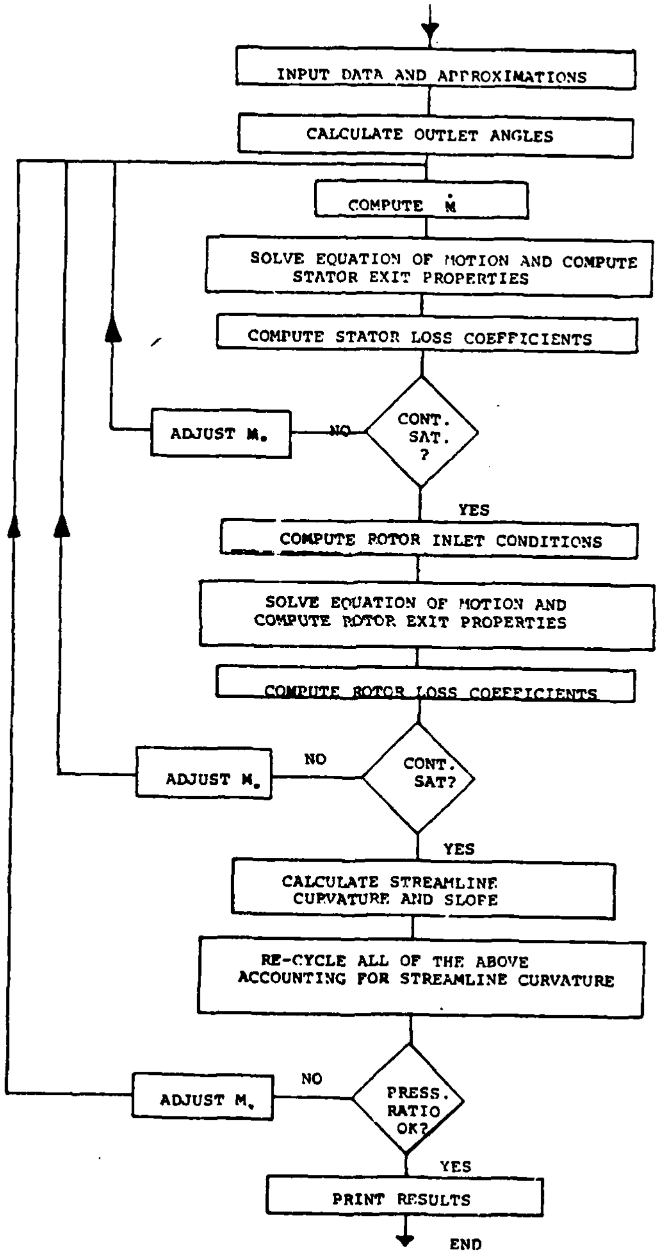
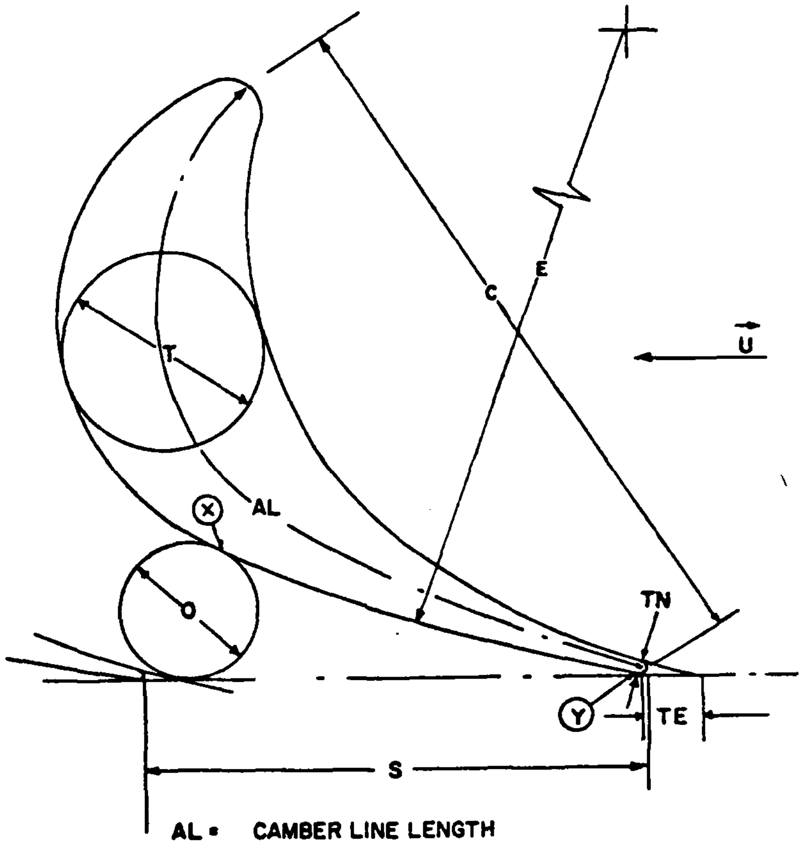


FIGURE A-1: PROGRAM FLOWCHART



AL = CAMBER LINE LENGTH
C = CHORD
O = THROAT DIAMETER
E = CURVATURE RADIUS
S = SPACING
T = MAXIMUM THICKNESS

TE = TRAILING EDGE THICKNESS PROJECTED IN PERIPHERAL DIRECTION

TN = TRAILING EDGE THICKNESS, NORMAL TO FLOW DIRECTION

FIGURE A-2: BLADE NOMENCLATURE

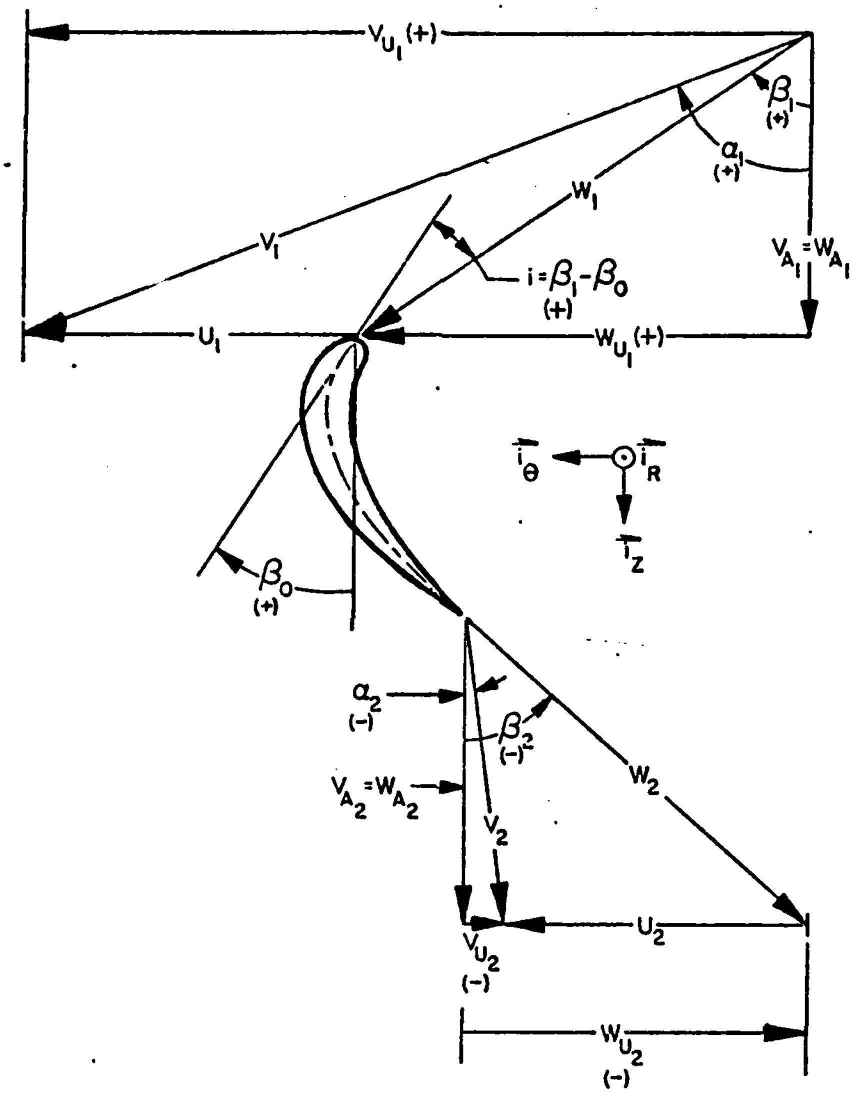


FIGURE A-3: VELOCITY DIAGRAM NOMENCLATURE

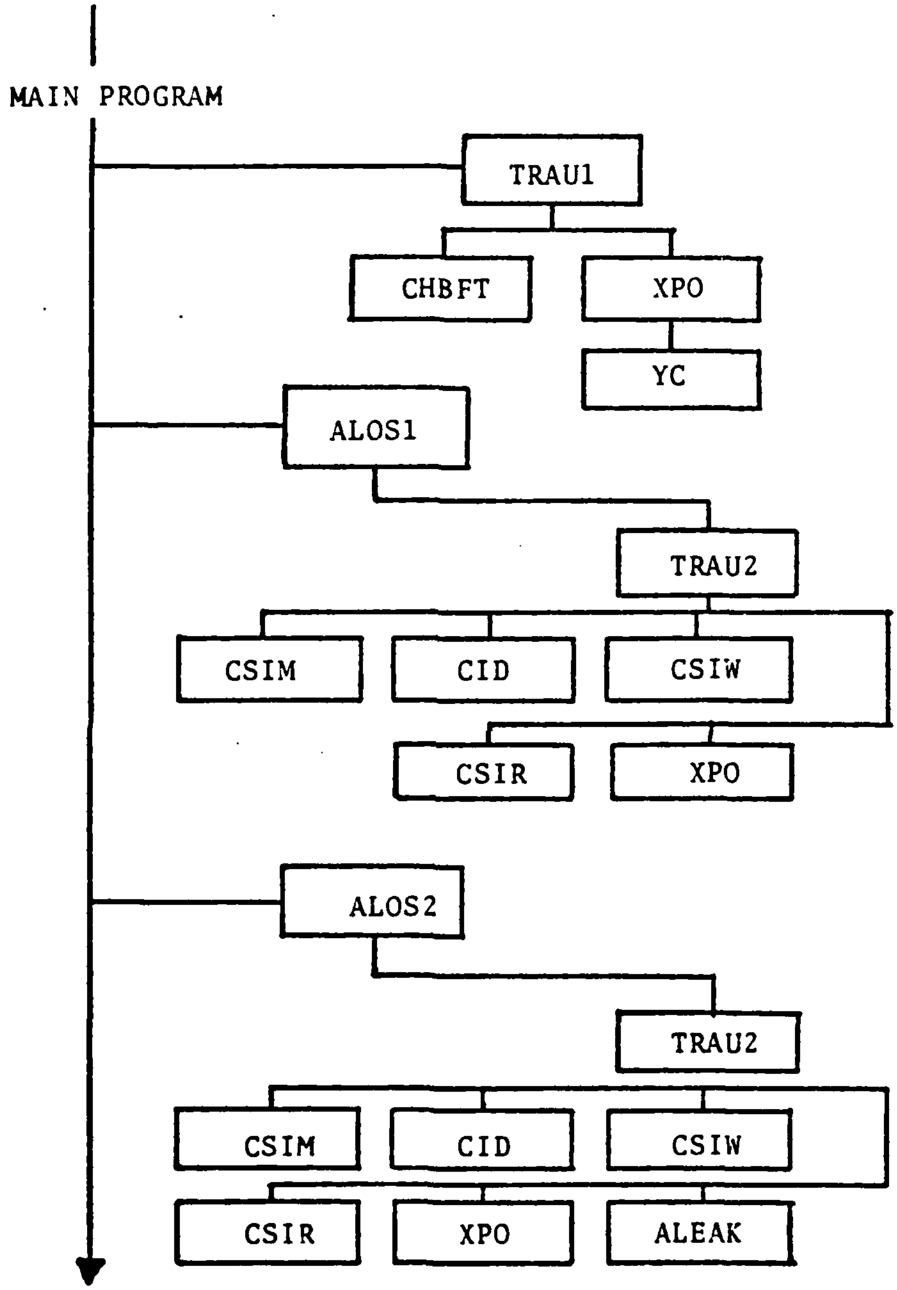


FIGURE A-4: INTERCONNECTION OF THE SUBROUTINES IN THE TRAUPEL METHOD

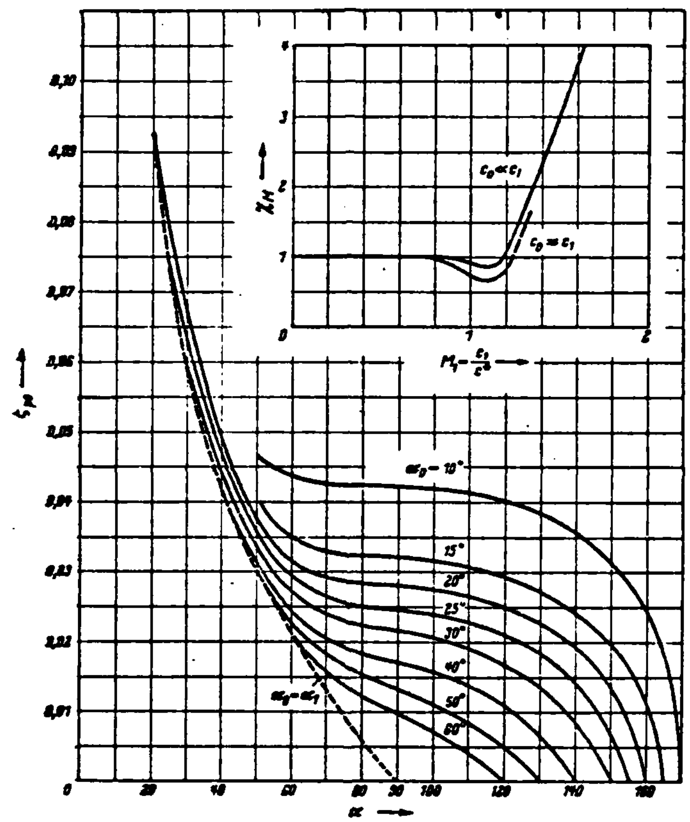


Abb. 8.4.2 Grundwert ζ_{p0} des Profilverlustes für Beschleunigungsgitter und Machzahlkorrektur χ_M

FIGURE A-5: INITIAL PROFILE LOSS COEFFICIENT AND MACH NUMBER CORRECTION FROM TRAUPEL

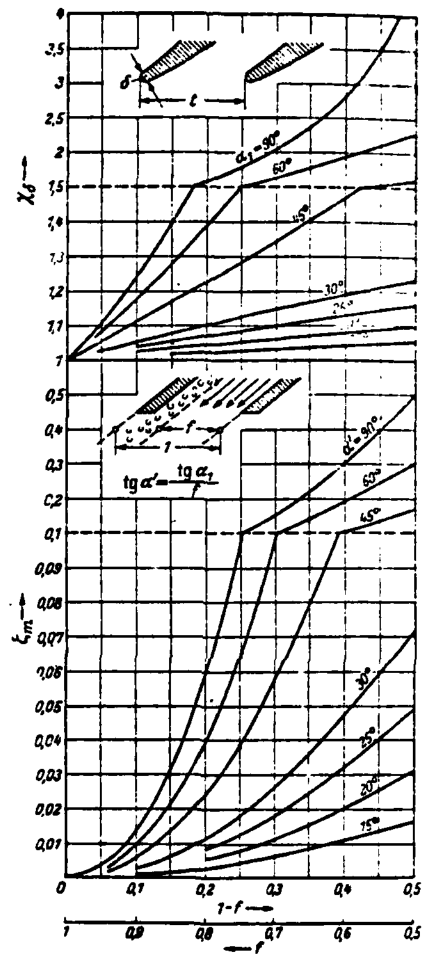


Abb. 8.4.4. Korrekturfaktor χ_δ und Mischverlust ζ_m infolge endlicher Austrittskantendicke oder Ablösung

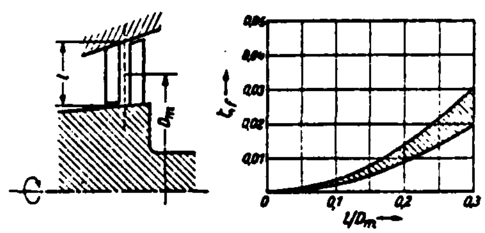


Abb. 8.4.5 Fächerverlust ζ_f

FIGURE A-6: T.E.THICKNESS CORRECTION FACTOR, MIXING LOSS COEFFICIENT AND FAN LOSS COEFFICIENT FROM TRAUPEL

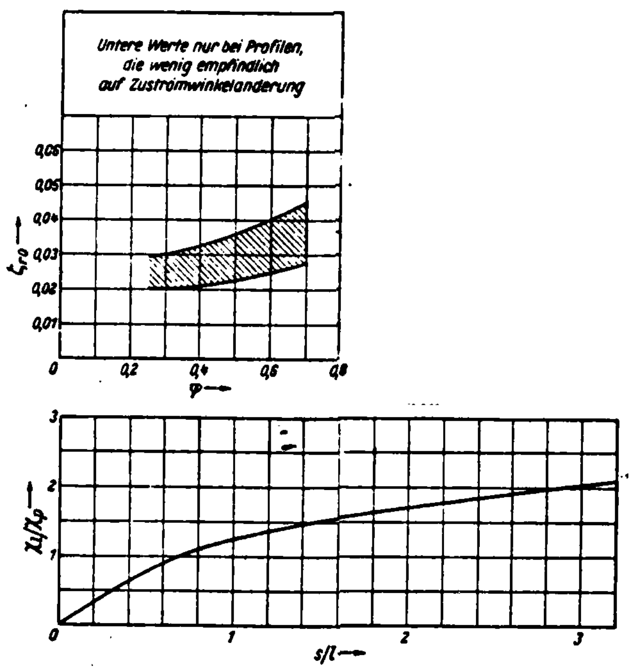


Abb. 8.4.7 Randverlust in Turbinenschaufelungen

FIGURE A-7: "REMAINING" LOSS COEFFICIENT FROM TRAUPEL

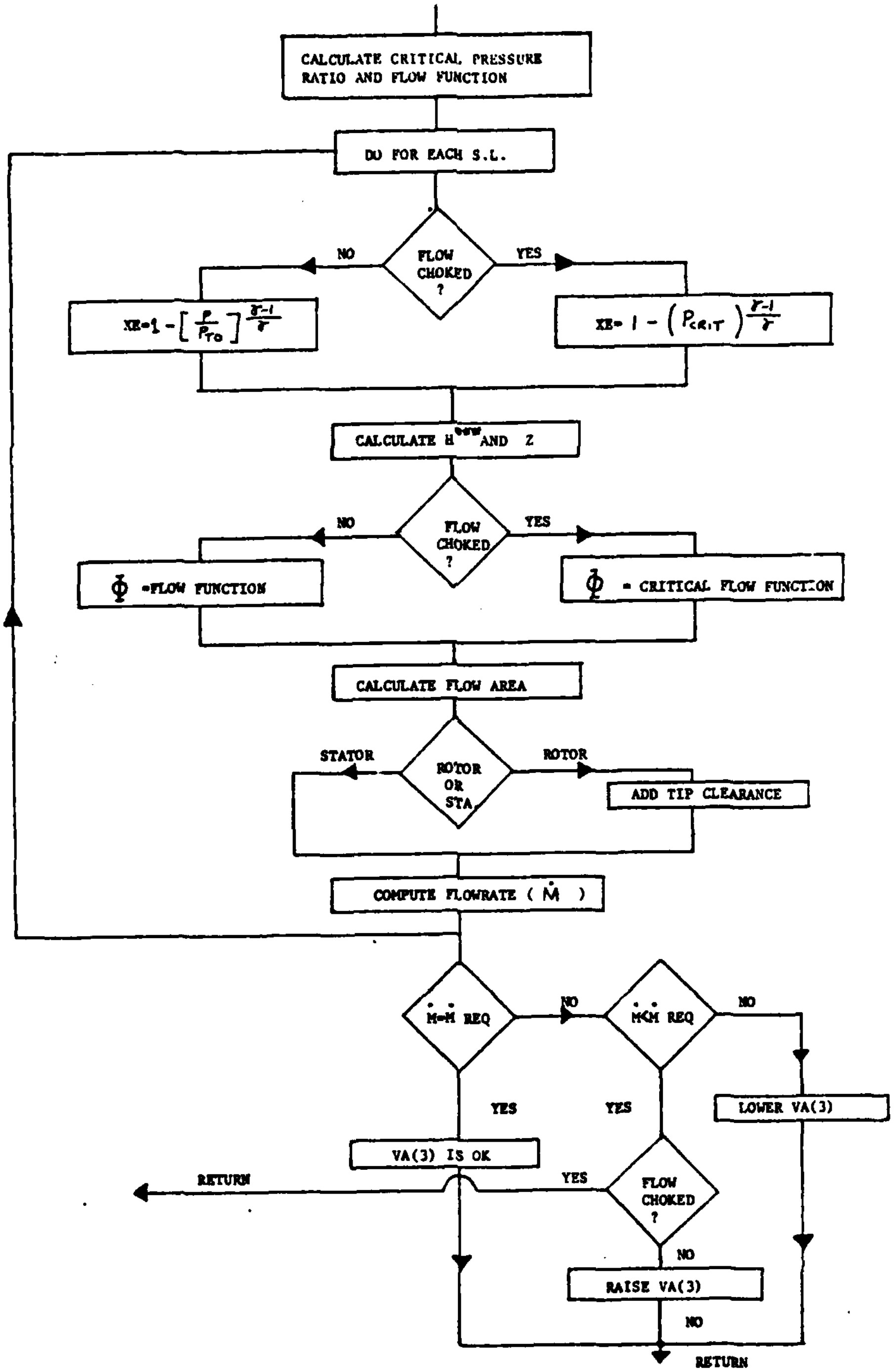


FIGURE A-8: SUBROUTINE FLOWR FLOWCHART

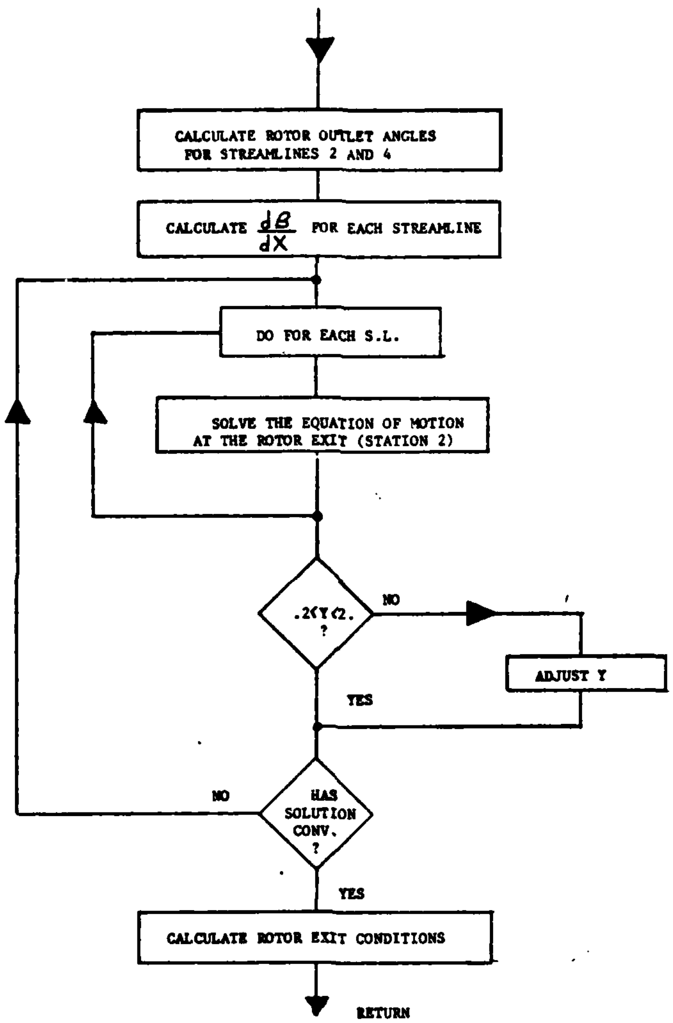


FIGURE A-9: SUBROUTINE ROTO2 FLOWCHART

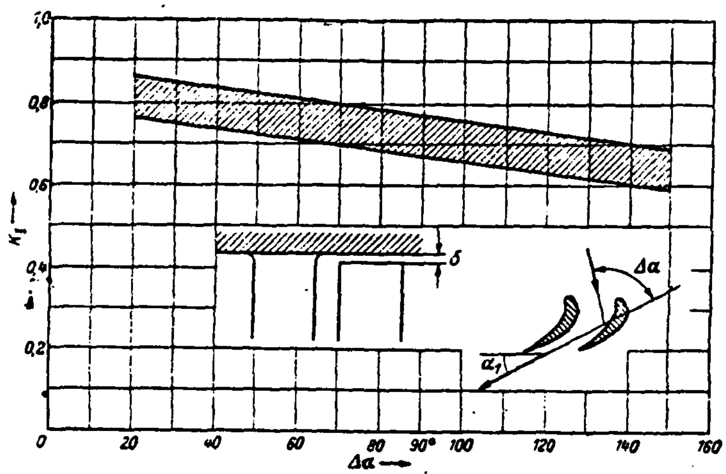


Abb. 8.4.11 Faktor K_I für Spaltverlustberechnung

FIGURE A-10: TIP LEAKAGE LOSS COEFFICIENT PLOT FROM TRAUPEL

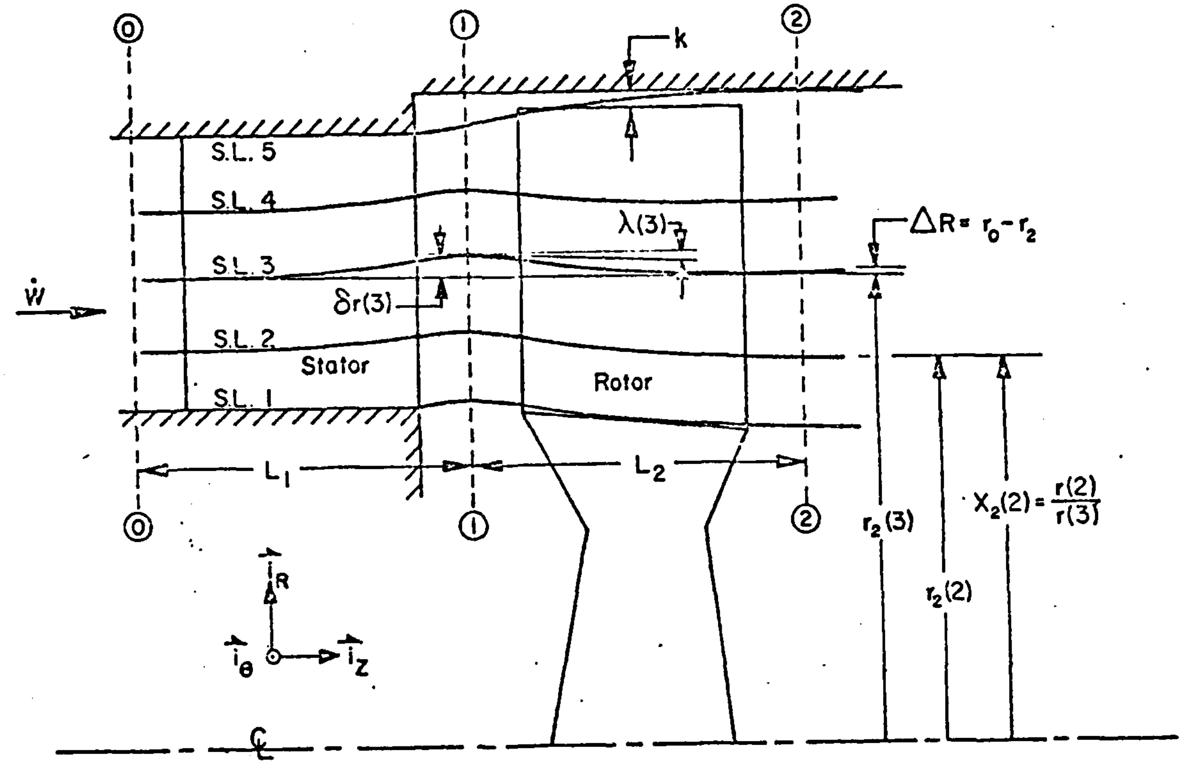


FIGURE A-11: STREAMLINE COORDINATES

APPENDIX: B

DERIVATION OF EQUATIONS USED IN THE PROGRAM

B-1. EQUATION OF MOTION FOR RELATIVE FLOW:

The equation of motion for relative flow Ref. [5] is

$$\nabla H_R = \vec{W} \times \left(\nabla \times \vec{W} + 2\vec{\omega} \right) + T \nabla S \tag{B-1}$$

Using cylindrical coordinates, the terms of EQN (B-1) may be expressed as follows:

$$\nabla H_R = \frac{i_\theta}{r}\frac{\partial H_R}{\partial \theta} + i_z \frac{\partial H_R}{\partial z} + i_r \frac{\partial H_R}{\partial r} \tag{B-2}$$

$$\nabla \times \vec{W} = \begin{vmatrix} i_\theta & \dfrac{i_z}{r} & \dfrac{i_r}{r} \\ \dfrac{\partial}{\partial \theta} & \dfrac{\partial}{\partial z} & \dfrac{\partial}{\partial r} \\ rW_u & W_a & W_r \end{vmatrix}$$

$$= i_\theta \left[\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r} \right] + \frac{i_z}{r} \left[\frac{\partial (rW_u)}{\partial r} - \frac{\partial W_r}{\partial \theta} \right] + \frac{i_r}{r} \left[\frac{\partial W_a}{\partial \theta} - \frac{\partial (rW_u)}{\partial z} \right] \tag{B-3}$$

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$$\vec{W} \times (\nabla \times \vec{W}) =$$

$$\begin{vmatrix} i_\theta & i_z & i_r \\ W_u & W_a & W_r \\ \left[\dfrac{\partial W_r}{\partial z} - \dfrac{\partial W_a}{\partial r}\right] & \dfrac{1}{r}\left[\dfrac{\partial (rW_u)}{\partial r} - \dfrac{\partial W_r}{\partial \theta}\right] & \dfrac{1}{r}\left[\dfrac{\partial W_a}{\partial \theta} \quad \dfrac{\partial (rW_u)}{\partial z}\right] \end{vmatrix}$$

$$= i_\theta \left[W_a \frac{1}{r}\left(\frac{\partial W_a}{\partial \theta} - \frac{\partial (rW_u)}{\partial z}\right) - W_r \frac{1}{r}\left(\frac{\partial (rW_u)}{\partial r} - \frac{\partial W_r}{\partial \theta}\right)\right] +$$

$$i_z \left[W_r \left(\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r}\right) - W_u \frac{1}{r}\left(\frac{\partial W_a}{\partial \theta} - \frac{\partial (rW_u)}{\partial z}\right)\right] +$$

$$i_r \left[W_u \frac{1}{r}\left(\frac{\partial (rW_u)}{\partial r} - \frac{\partial W_r}{\partial \theta}\right) - W_a \left(\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r}\right)\right]$$

(B-4)

$$\vec{W} \times 2\vec{\omega} = \left[i_\theta W_u + i_z W_a + i_r W_r \right] \times \left[i_z 2\omega \right]$$

$$= i_r (2\omega W_u) - i_\theta (2\omega W_r)$$

(B-5)

$$T\nabla S = T\left[i_\theta \frac{1}{r}\frac{\partial S}{\partial \theta} + i_z \frac{\partial S}{\partial z} + i_r \frac{\partial S}{\partial r}\right] \tag{B-6}$$

Combining equations (B-1) through (B-6) the terms in (B-2) can be written as:

$$\frac{1}{r}\frac{\partial H_R}{\partial \theta} = \frac{W_a}{r}\left[\frac{\partial W_a}{\partial \theta} - \frac{\partial (r W_u)}{\partial z}\right] - \frac{W_r}{r}\cdot\left[\frac{\partial (r W_u)}{\partial r} - \frac{\partial W_r}{\partial \theta}\right] - 2\omega W_r + \frac{T}{r}\frac{\partial S}{\partial \theta} \tag{B-7}$$

$$\frac{\partial H_R}{\partial z} = W_r\left[\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r}\right] - \frac{W_u}{r}\left[\frac{\partial W_a}{\partial \theta} - \frac{\partial (r W_u)}{\partial z}\right] + T\frac{\partial S}{\partial z} \tag{B-8}$$

$$\frac{\partial H_R}{\partial r} = \frac{W_u}{r}\left[\frac{\partial (r W_u)}{\partial r} - \frac{\partial W_r}{\partial \theta}\right] - W_a\left[\frac{\partial W_r}{\partial z} - \frac{\partial W_a}{\partial r}\right] + 2\omega W_u + T\frac{\partial S}{\partial r} \tag{B-9}$$

Since the flow has been assumed to be axisymmetric, all derivatives with respect to θ are zero. Thus, Equations (B-7), (B-8) and (B-9) reduce to, respectively:

$$0 = -\frac{W_a}{r}\frac{\partial(rW_u)}{\partial z} - \frac{W_r}{r}\frac{\partial(rW_u)}{\partial r} - 2\omega W_r \tag{B-10}$$

$$\frac{\partial H_R}{\partial z} = W_r\frac{\partial W_r}{\partial z} - W_r\frac{\partial W_a}{\partial r} + \frac{W_u}{r}\cdot\frac{\partial(rW_u)}{\partial z} + T\cdot\frac{\partial s}{\partial z} \tag{B-11}$$

$$\frac{\partial H_R}{\partial r} = \frac{W_u}{r}\frac{\partial(rW_u)}{\partial r} - W_a\frac{\partial W_r}{\partial z} + W_a\frac{\partial W_a}{\partial r} + 2\omega W_u + T\frac{\partial s}{\partial r} \tag{B-12}$$

Equation (B-10) may be written as

$$\frac{\partial(rW_u)}{\partial z} = -\frac{W_r}{W_a}\frac{\partial(rW_u)}{\partial r} - 2\omega r\frac{W_r}{W_a} \tag{B-13}$$

Substituting into equation (B-11),

$$\frac{\partial H_R}{\partial z} = -\frac{W_u}{r}\frac{W_r}{W_a}\frac{\partial(rW_u)}{\partial r} + W_r\frac{\partial W_r}{\partial z} - W_r\frac{\partial W_a}{\partial r} - 2\omega\frac{W_u W_r}{W_a} - T\frac{\partial s}{\partial z} \tag{B-14}$$

Multiplying equation (B-9) by Wr and Equation (B-14) by Wa results in

$$W_r \frac{\partial H_R}{\partial r} = \frac{W_u W_r}{r} \frac{\partial (r W_u)}{\partial r} - W_a W_r \frac{\partial W_r}{\partial z} +$$

$$W_a W_r \frac{\partial W_a}{\partial r} + 2\omega W_u W_r + W_r T \frac{\partial S}{\partial r} \qquad \text{(B-15)}$$

and

$$W_a \frac{\partial H_R}{\partial z} = - \frac{W_u W_r}{r} \frac{\partial (r W_u)}{\partial r} + W_a W_r \frac{\partial W_r}{\partial z} -$$

$$W_a W_r \frac{\partial W_a}{\partial r} - 2\omega W_u W_r + W_a T \frac{\partial S}{\partial z}$$

(B-16)

Adding these two equations yields

$$W_r \frac{\partial H_R}{\partial r} + W_a \frac{\partial H_R}{\partial z} = T\left[W_r \frac{\partial S}{\partial r} + W_a \frac{\partial S}{\partial z}\right] \qquad \text{(B-17)}$$

Since the flow has been assumed to be adiabatic, the total relative enthalpy, H_R, is constant along a streamline. Thus,

$$\nabla H_R = 0 = W_a \frac{\partial H_R}{\partial z} + W_r \frac{\partial H_R}{\partial r} \qquad \text{(B-18)}$$

and re-arranging,

$$\frac{\partial H_R}{\partial z} = - \frac{W_r}{W_a} \frac{\partial H_R}{\partial r} \qquad \text{(B-19)}$$

From equation (B-19), eq. (B-17) can be written as

$$\frac{\partial S}{\partial z} = - \frac{W_r}{W_a} \frac{\partial S}{\partial r} \qquad \text{(B-20)}$$

Substituting Eq.s (B-19) and (B-20) into equation (B-15) gives

$$-\frac{W_r}{W_a}\frac{\partial H_R}{\partial r} = -\frac{W_u}{r}\frac{W_r}{W_a}\frac{\partial (rW_u)}{\partial r} + W_r\frac{\partial W_r}{\partial z} - W_r\frac{\partial W_a}{\partial r} - 2\omega\frac{W_u W_r}{W_a} - \frac{W_r}{W_a}T\frac{\partial s}{\partial r} \qquad \text{(B-21)}$$

Multiplying Equation (B-21) by $\frac{-W_a}{W_R}$ yields

$$\frac{\partial H_R}{\partial r} = \frac{W_u}{r}\frac{\partial (rW_u)}{\partial r} - W_a\frac{\partial W_r}{\partial z} + W_a\frac{\partial W_a}{\partial r} + 2\omega W_u + T\frac{\partial s}{\partial r} \qquad \text{(B-22)}$$

This expression is identical to equation (B-21) and is the equation which must be solved. It must be put into a form which can be solved by the computer. Re-writing equation (B-22) given that

$$W_a\frac{\partial W_a}{\partial r} = \frac{1}{2}\frac{\partial (W_a^2)}{\partial r}$$

yields

$$\frac{\partial (W_a^2)}{\partial r} - 2W_a\frac{\partial W_r}{\partial z} + \frac{2W_u}{r}\frac{\partial (rW_u)}{\partial r} + 4\omega W_u - 2\frac{\partial H_R}{\partial r} + 2T\frac{\partial s}{\partial r} = 0 \qquad \text{(B-23)}$$

The relative enthalpy can be written

$$H_R = h_1 + \frac{W_1^2}{2g_cJ} - \frac{U_1^2}{2g_cJ} = h_2 + \frac{W_2^2}{2g_cJ} - \frac{U_2^2}{2g_cJ} \qquad \text{(B-24)}$$

The equivalent enthalpy, defined in ref. [1] is

$$H_E = h_1 + \frac{W_1^2}{2g_cJ} + \frac{U_2^2 - U_1^2}{2g_cJ} \tag{B-25}$$

Hence, the relative enthalpy can be written as

$$H_R = H_E - \frac{U_2^2}{2} \tag{B-26}$$

Also, the turbine outlet static temperature can be written as

$$T_2 = \frac{H_E}{C_p} - \frac{W_2^2}{2C_p} \tag{B-27}$$

Substituting Eq. (B-26) and Eq. (B-27) into Eq. (B-23) and applying Eq. (B-21) to the rotor exit, gives

$$\frac{\partial(W_a^2)}{\partial r_2} - 2W_{a_2}\frac{\partial W_{r_2}}{\partial z} + 2\frac{W_{u_2}}{r_2}\frac{\partial(r_2 W_{u_2})}{\partial r_2} + 4\omega W_{u_2} - 2\frac{\partial}{\partial r_2}\left[H_E - \frac{U_2^2}{2}\right] + 2\left[\frac{H_E}{C_p} - \frac{W_2^2}{2C_p}\right]\frac{\partial S_2}{\partial r_2} = 0 \tag{B-28}$$

Given the relationships:

$$\mathrm{TAN}^2\lambda = \frac{W_r^2}{W_a^2}$$

and $$1 + \tan^2\lambda = \frac{1}{\cos^2\lambda}$$

Equation (B-28) can be written as

$$\frac{\partial(W_{a_2}^2)}{\partial r_2} - 2W_{a_2}\frac{\partial W_{r_2}}{\partial z} - \frac{W_{a_2}^2}{C_p\cos^2\lambda_2}\cdot\frac{\partial S_2}{\partial r_2} + 2\cdot$$
$$\frac{W_{u_2}}{r_2}\cdot\frac{\partial(r_2W_{u_2})}{\partial r_2} + 4\omega W_{u_2} - 2\frac{\partial H_E}{\partial r_2} +$$
$$\frac{\partial(U_2^2)}{\partial r_2} + \frac{1}{C_p}\left[2H_E - W_{u_2}^2\right]\frac{\partial S_2}{\partial r_2} \qquad \text{(B-29)}$$

and substituting $\frac{\partial(U_2^2)}{\partial r_2} = 2\omega^2 r_2$ into equation (B-29) gives

$$\frac{\partial(W_{a_2}^2)}{\partial r_2} - 2W_{a_2}\frac{\partial W_{r_2}}{\partial z} - \frac{W_{a_2}^2}{C_p\cos^2\lambda_2}\frac{\partial S_2}{\partial r_2} -$$
$$2\frac{W_{u_2}}{r_2}\frac{\partial(r_2W_{u_2})}{\partial r_2} + 4\omega W_{u_2} - 2\frac{\partial H_E}{\partial r_2} +$$
$$2\omega^2 r_2 + \frac{1}{C_p}\left[2H_E - W_{u_2}^2\right]\frac{\partial S_2}{\partial r_2} \qquad \text{(B-30)}$$

Multiplying Eq. (B-30) by $\left(\frac{r_m}{W_{a_m}^2}\right)$ results in the dimensionless form of Equation (B-29):

$$\frac{r_{2m}}{W_{a_{2m}}^2}\ \frac{\partial (W_{a_2}^2)}{\partial r_2} - 2\ \frac{W_{a_2}}{W_{a_{2m}}^2}\ \frac{W_{a_2}}{W_{a_2}}\ r_{2m}\ \frac{\partial (W_{r_2})}{\partial z} -$$

$$\frac{W_{a_2}^2\ r_{2m}}{W_{a_{2m}}^2\ c_p \cos^2\lambda_2}\ \frac{\partial S_2}{\partial r_2} + 2\ \frac{W_{u_2} W_{a_2} r_{2m}}{W_{a_{2m}} W_{a_2} r_2} \cdot \frac{\partial \left[\frac{r_2\ W_{u_2} W_{a_2}}{r_{2m} W_{a_{2m}} W_{a_2}}\right]}{\partial (r_2/r_{2m})}$$

$$+4\ \frac{\omega\, r_{2m} W_{u_2} W_{a_2}}{W_{a_{2m}}^2\ W_{a_2}} - 2\ \frac{r_{2m}}{W_{a_{2m}}^2}\ \frac{\partial H_E}{\partial r_2} + \frac{2\omega^2 r_2\, r_{2m}}{W_{a_{2m}}^2} +$$

$$\frac{r_{2m}}{C_p}\left[\frac{\partial H_E}{W_{a_{2m}}^2} - \frac{W_{u_2}^2\ W_{a_2}^2}{W_{a_{2m}}^2\ W_{a_2}^2}\right]\ \frac{\partial S_2}{\partial r_2} \tag{B-31}$$

Introducing the non-dimensional quantities

$$Y = \frac{W_a}{W_{a_m}} \tag{B-32}$$

$$X = \frac{r}{r_m} \tag{B-33}$$

$$S^* = \frac{S}{c_p} \tag{B-34}$$

Equation (B-31) is written as

$$\frac{\partial (Y^2)}{\partial X} - 2\,\frac{Y^2}{W_a}\,r_m\,\frac{\partial W_r}{\partial z} - \frac{Y^2}{\cos^2\lambda}\,\frac{\partial s^*}{\partial X} +$$

$$2Y\,\frac{\tan\beta}{X}\,\frac{\partial (XY\tan\beta)}{\partial X} + 4\,\frac{U_m Y \tan\beta}{W_{a_m}} -$$

$$\frac{2}{W_{a_m}^2}\,\frac{\partial H_E}{\partial X} + 2\,\frac{U_m U_2}{W_{a_m}^2} + \left[\frac{2H_E}{W_{a_m}^2} - \right.$$

$$\left. Y^2\tan^2\beta\right]\frac{\partial s^*}{\partial X} = 0 \qquad \text{(B-35)}$$

The fourth term of Eq. (B-35) is

$$2Y\,\frac{\tan\beta}{X}\,\frac{\partial (XY\tan\beta)}{\partial X} = 2Y\,\frac{\tan\beta}{X}\left[XY\right.$$

$$\left.\frac{\partial \tan\beta}{\partial X} + X\tan\beta\,\frac{\partial Y}{\partial X} + Y\tan\beta\,\frac{\partial X}{\partial X}\right]$$

$$= 2Y^2\tan\beta\,\frac{\partial \tan\beta}{\partial X} + 2Y\tan^2\beta\,\frac{\partial Y}{\partial X} +$$

$$2\,\frac{Y^2}{X}\tan^2\beta$$

also, $$\frac{\partial \tan\beta}{\partial X} = \frac{1}{\cos^2\beta}\,\frac{\partial \beta}{\partial X}$$

and $$2Y\tan^2\beta\,\frac{\partial Y}{\partial X} = \tan^2\beta\,\frac{\partial (Y^2)}{\partial X}$$

Therefore, equation (B-35) can be written

$$\frac{\partial (Y^2)}{\partial X}\left(1+\tan^2\beta\right) - 2\,\frac{Y^2}{W_a}\,r_m\,\frac{\partial W_r}{\partial z} - \frac{Y^2}{\cos^2\lambda}\,\frac{\partial s^*}{\partial X} +$$
$$2Y^2\,\frac{\tan\beta}{\cos^2\beta}\,\frac{\partial \beta}{\partial X} + 2\,\frac{Y^2}{X}\tan^2\beta + \frac{4U_m Y\tan\beta}{W_{a_m}} -$$
$$\frac{2}{W_{a_m}^2}\,\frac{\partial H_E}{\partial X} + 2\,\frac{U_m U_z}{W_{a_m}^2} + \left[\frac{2H_E}{W_{a_m}^2} - Y^2\tan^2\beta\right]\frac{\partial s^*}{\partial X}$$

(B-36)

Multiplying Eq. (B-36) by $\left(\frac{\cos^2\beta}{Y^2}\right)$ and observing that $\left(1+\tan^2\beta = \frac{1}{\cos^2\beta}\right)$,

$$\frac{1}{Y^2}\,\frac{\partial (Y^2)}{\partial X} + \cos^2\beta\left[-\frac{2r_m}{W_a}\,\frac{\partial W_r}{\partial z} - \frac{1}{\cos^2\lambda}\,\frac{\partial s^*}{\partial X}\right] +$$
$$2\tan\beta\,\frac{\partial \beta}{\partial X} + \frac{2}{X}\sin^2\beta + \frac{4U_m\sin\beta\cos\beta}{W_{a_m}Y} + \frac{2U_m U_z\cos^2\beta}{W_{a_m}^2 Y^2}$$
$$-\frac{2\cos^2\beta}{W_{a_m}^2}\,\frac{\partial H_E}{\partial X} + \left[\frac{2H_E\cos^2\beta}{W_{a_m}^2 Y^2} - \sin^2\beta\right]\frac{\partial s^*}{\partial X} = 0$$

(B-37)

To account for streamline curvature the following terms are introduced:

$$\cos^2\lambda = \frac{L^2}{L^2 + \left(\frac{\Delta R}{2}\right)^2}$$

(B-38)

where λ, the angle between the axial and radial components of velocity at a point, is approximated as the average value between two stations.

Also,

$$K \frac{\delta R}{L^2} = - \frac{1}{W_a} \frac{\partial W_r}{\partial z}$$

(B-39)

where δr is the streamline shift throught the rotor defined as

$$\delta r = r_{\substack{\text{ROTOR}\\ \text{OUTLET}}} - r_{\substack{\text{ROTOR}\\ \text{INLET}}} \qquad \text{(B-40)}$$

Substituting Eqs. (B-38) and (B-39) into (B-37) yields

$$\frac{d(\ln Y^2)}{dX} = -\cos^2\beta \left[-\left(2 K r_m \frac{\delta R}{L^2}\right) - \left(\frac{L^2 + (\Delta R)^2}{L^2}\right) \frac{ds^*}{dX} \right]$$

$$- 2 \tan\beta \frac{d\beta}{dX} - \frac{2}{X} \sin^2\beta - \frac{4 U_m \sin\beta \cos\beta}{W_{a_m} Y} -$$

$$\frac{2 U_m U_a \cos^2\beta}{W_{a_m}^2 Y^2} + \frac{2\cos^2\beta}{W_{a_m}^2 Y^2} \frac{dH_E}{dX} - \left[\frac{2 H_E \cos^2\beta}{W_{a_m}^2 Y^2} - \sin^2\beta \right] \frac{ds^*}{dX}$$

(B-41)

To obtain a dimensionless equation, the term

$$C_1 = 2 g_c J$$

is introduced into Eq. (B-41) giving

$$\frac{d(\ln Y^2)}{dX} = -\cos^2\beta\left[-\left(K \frac{2(\delta r)\, r_m}{L^2}\right) - \left(\frac{L^2 + (\Delta R)^2}{L^2}\right)\frac{dS^*}{dX}\right] -$$

$$2\tan\beta \frac{d\beta}{dX} - \frac{2}{X}\sin^2\beta - \frac{4U_m \sin\beta\cos\beta}{Wa_m Y} - \frac{2U_m U_2 \cos^2\beta}{Wa_m^2 Y^2} +$$

$$\frac{C_1 \cos^2\beta}{Wa_m^2 Y^2}\frac{dH_E}{dX} - \left[\frac{C_1 H_E \cos^2\beta}{Wa_m^2 Y^2} - \sin^2\beta\right]\frac{dS^*}{dX}$$

(B-42)

Equation (B-42) is the form of equation of motion used in the computer program.

B-2. EQUATION OF MOTION FOR ABSOLUTE FLOW

The equation of motion for absolute flow

$$\nabla H = \vec{V} \times (\nabla \times \vec{V}) + T\nabla S$$

(B-43)

Differs from the equation of motion for relative flow

$$\nabla H_R = \vec{W} \times (\nabla \times \vec{W} + 2\vec{\omega}) + T\nabla S \tag{B-44}$$

only by the term $\vec{W} \times 2\vec{\omega}$ which is the Coroiolis acceleration. To obtain the programmed form of the equation of motion for the stator, the previous derivation is followed, but with $U = 0$, H_E becomes H, W becomes V, and β becomes α.

B-3 THE AREA RESTRICTION FACTOR Z

The condition at the outlet of a blade row with boundary layers on both sides of the flow channel is shown in Fig. B-1. The flow is considered to be turbulent within the boundary layer while, outside the layer, the velocity of the flow is the theoretical velocity. Assuming a power-law velocity profile, the velocity may be written,

$$\frac{u}{V_{TH}} = \left[\frac{y}{\delta}\right]^m \tag{B-45}$$

The mass flow rate exiting the blade row can be expressed as

$$\dot{m} = \rho_{TH} V_{TH} \cos\alpha_d \left[S - \frac{t}{\cos\alpha^*_d} - \frac{\Sigma\delta}{\cos\alpha_d}\right] + \Sigma \int_0^\delta u\rho\, dy \tag{B-46}$$

where ρ_{th} and V_{th} represent the ideal conditions for an isentropic expansion through the blade row to the discharge

pressure Pd, which is assumed to be constant across the blade spacing. The discharge angle of the flow leaving the blade row is closely approximated by the expression [Ref. 1]

$$\alpha_d = \cos^{-1}\left[\frac{a}{S - \frac{t}{\cos^{*}\alpha_d}}\right] \tag{B-47}$$

Inserting Eq. (B-47) into (B-46) and reducing yields

$$\dot{m} = \rho_{TH} V_{TH}\, a \left[1 - \Sigma \frac{\delta}{a}\left(1 - \int_0^1 \frac{\rho}{\rho_{TH}} \frac{u}{u_{TH}}\, d\eta\right)\right] \tag{B-48}$$

Assuming a perfect gas

$$\frac{\rho}{\rho_{TH}} = \frac{T_{TH}}{T} = \frac{T_{TO} - (T_{TO} - T_{TH})}{T_{TO} - (T_{TO} - T_{TH})\left(\frac{u}{V_{TH}}\right)^2} \tag{B-49}$$

Defining

$$X_E = 1 - \left(\frac{P_d}{P_{TO}}\right)^{\frac{\gamma-1}{\gamma}} \tag{B-50}$$

Equation (B-49) can be written

$$\frac{\rho}{\rho_{TH}} = \frac{1 - X_E}{1 - X_E\left(\frac{u}{V_{TH}}\right)^2} \tag{B-51}$$

Substituting Eq. (B-51) into (B-45) yields

$$\dot{m} = \rho_{TH} V_{TH}\, a \left[1 - \Sigma \frac{\delta}{a}\left(1 - (1 - X_E)\int_0^1 \frac{\eta^m}{1 - X_E \eta^{2m}}\, d\eta\right)\right] \tag{B-52}$$

Using the displacement thickness given by

$$\delta^* = \delta \cdot \left[1 - (1 - X_E) \int_0^1 \frac{\eta^m}{(1 - X_E \eta^{2m})} d\eta \right]$$

(B-53)

the mass flow rate can be written as

$$\dot{m} = \rho_{TH} V_{TH}\, a \left[1 - \frac{\Sigma \delta^*}{a} \right]$$

(B-54)

The loss coefficient, expressed in terms of average kinetic energy lost is

$$\zeta = \frac{\Delta E}{\dot{m}\left(\frac{V_{TH}^2}{2}\right)} = 1 - \frac{E}{\dot{m}\ \frac{V_{TH}^2}{2}}$$

(B-55)

where E is the actual kinetic energy of the flow, given by

$$E = \rho_{TH} V_{TH} (a - \Sigma\delta) \frac{V_{TH}}{2} + \Sigma \int_0^{\delta} \rho u \frac{u^2}{2}\, dy$$

(B-56)

Substituting Eq. (B-51) into (B-56) gives

$$E = \rho_{TH} \frac{V_{TH}^2}{2} a \left[1 - \Sigma \frac{\delta}{a} \left(1 - (1 - X_E) \int_0^1 \frac{\eta^{3m}}{(1 - X_E \eta^{2m})} d\eta \right) \right]$$

(B-57)

The energy thickness is written as

$$\delta^{***} = \delta\left[1 - (1-X_E)\int_0^1 \frac{\eta^{3m}}{(1-X_E\,\eta^{2m})}\,d\eta\right] \tag{B-58}$$

The loss coefficient can therefore be written as

$$\zeta = 1 - \frac{1 - \Sigma\,\dfrac{\delta^{***}}{a}}{1 - \Sigma\,\dfrac{\delta^{*}}{a}} \tag{B-59}$$

The area restriction factor Z, is the fraction of the flow area through which the uniform theoretical velocity would produce the actual flow rate, thus

$$Z = \frac{\Sigma\,\delta^{*}}{a} \tag{B-60}$$

Defining the energy parameter (a form factor) as

$$H^{***} = \frac{\delta^{***}}{\delta^{*}} \tag{B-61}$$

using Equations (B-59) and (B-61), Eq. (B-60) becomes

$$Z = \frac{H^{***} - 1}{H^{***} - 1 + \zeta_P} \tag{B-62}$$

where ξp is the profile loss coefficient.

B-4. THE ENERGY PARAMETER, H***

In Equations (B-53) and (B-58) the denominator of the integrand is expanded using the binomial theorem, so that

$$\left(1 - X_E \eta^{2m}\right)^{-1} = 1 + X_E \eta^{2m} + X_E^{\,2} \eta^{4m} + X_E^{\,3} \eta^{6m} + \ldots \tag{B-63}$$

The integral of Equation (B-58) is now written as

$$\int_0^1 \frac{\eta^{3m}\, d\eta}{1 - X_E \eta^{2m}} = \int_0^1 \left[\eta^{3m} + X_E \eta^{5m} + X_E^{\,2} \eta^{7m} + X_E^{\,3} \eta^{9m} + X_E^{\,4} \eta^{11m} + \ldots\right] d\eta \tag{B-64}$$

which, on integration becomes

$$\int_0^1 \frac{\eta^{3m}}{1 - X_E \eta^{2m}}\, d\eta = \frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^{\,2}}{7m+1} + \frac{X_E^{\,3}}{9m+1} + \frac{X_E^{\,4}}{11m+1} + \ldots \tag{B-65}$$

Therefore, Equation (B-58) becomes.

$$\frac{\delta^{***}}{\delta} = 1 - \left[\frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^{2}}{7m+1} + \frac{X_E^{3}}{9m+1} + \frac{X_E^{4}}{11m+1}\right]\left(1 - X_E\right) \tag{B-66}$$

which can be written as

$$\frac{\delta^{***}}{\delta} = (X_E - 1)\left[\frac{1}{X_E - 1} + \frac{1}{3m+1} + \frac{X_E}{5m+1} + \frac{X_E^{\,2}}{7m+1} + \frac{X_E^{\,3}}{9m+1} + \frac{X_E^{\,4}}{11m+1}\right] \tag{B-67}$$

In a similar manner,

$$\frac{\delta^{*}}{\delta} = (X_E - 1)\left[\frac{1}{X_E - 1} + \frac{1}{m+1} + \frac{X_E}{3m+1} + \frac{X_E^{\,2}}{5m+1} + \frac{X_E^{\,3}}{7m+1} + \frac{X_E^{\,4}}{9m+1}\right] \tag{B-68}$$

Substituting Eq. (B-67) and Eq. (B-68) into Eq. (B-61), the equation for H*** used in the computer program is obtained:

$$H^{***} = \frac{\dfrac{1}{X-1} + \dfrac{1}{3m+1} + \dfrac{X_E}{5m+1} + \dfrac{X_E^{\,2}}{7m+1} + \dfrac{X_E^{\,3}}{9m+1} + \dfrac{X_E^{\,4}}{11m+1}}{\dfrac{1}{X_E-1} + \dfrac{1}{m+1} + \dfrac{X_E}{3m+1} + \dfrac{X_E^{\,2}}{5m+1} + \dfrac{X_E^{\,3}}{7m+1} + \dfrac{X_E^{\,4}}{9m+1}} \tag{B-69}$$

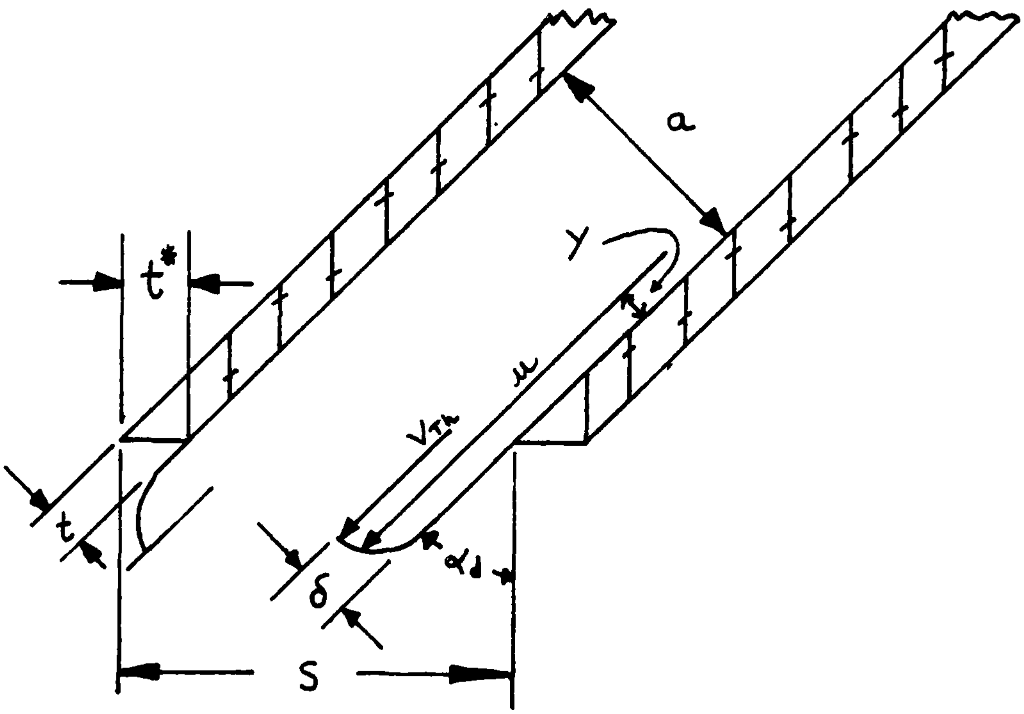

FIGURE B-1: BOUNDARY LAYER EFFECTS AT THE EXIT
OF A BLADE ROW

APPENDIX: C

PROGRAM SEGMENTATION ON THE HP-1000

Segmentation allows large programs to be run on the HP-1000. The program is divided by the programmer into a main program and several segments, which are stored on the disc. Each segment and the main program are then compiled and loaded. When the program is executed, the main program and its segments are called into memory individually, and only as they are needed for execution. In this manner, a program can run in a partition which is smaller than that program's total size.

When the main program has performed all executable statements, the first segment is called into memory by an EXEC call. The system then loads that segment from the disc into a memory block following the end of the main program. The process is illustrated in Figure C-1. Note; the main program plus the largest segment may not together exceed 29 k. Once a segment is in memory it can call another segment.

When executing, any segment can call any subroutine which is attached to the main program. It was this feature which allowed the present program to be run. All subroutines were placed within the main program. In fact, the main program consisted of nineteen subroutines and functions. A segment may not return to the main program. Communication of data

between the main program and the segments is accomplished through a common block.

The four segments of the present program are "MAIN", "SHORT", "PART 2" and "PART 3". The manner in which control is passed from the main program to the first segment and from the first segment to the second is as follows:

```
BLOCK DATA
.
.
.
END
PROGRAM THESS
DIMENSION INAM (3)
DATA INAM  /2HSH, 2HOR, 2HT  /
.
.
.
CALL EXEC (8, INAM)
END
PROGRAM SHORT (5)
DIMENSION INAM (3)
DIMENSION NAME (3)
DATA INAM  /2HSH, 2HOR, 2HT  /
DATA NAME /2HPA, 2HRT, 2H2  /
.
.
.
CALL EXEC (8, NAME)
```

```
END
PROGRAM PART 2 (5)
DIMENSION NAME (3)
DIMENSION NAMR (3)
DATA NAME  /2HPA, 2HRT, 2H2  /
DATA NAMR  /2HPA, 2HRT, 2H3  /
.
.
.
CALL EXEC (8, NAMR)
END
PROGRAM PART 3 (5)
DIMENSION NAME (3)
DIMENSION NAMR (3)
DATA NAME  /2HPA, 2HRT, 2H2  /
DATA NAMR  /2HPA, 2HRT, 2H3  /
.
.
.
END
```

The "(5)" after the program name indicates that it is a program segment. Note the manner in which the program name is put into a data statement using the Hollerith notation.

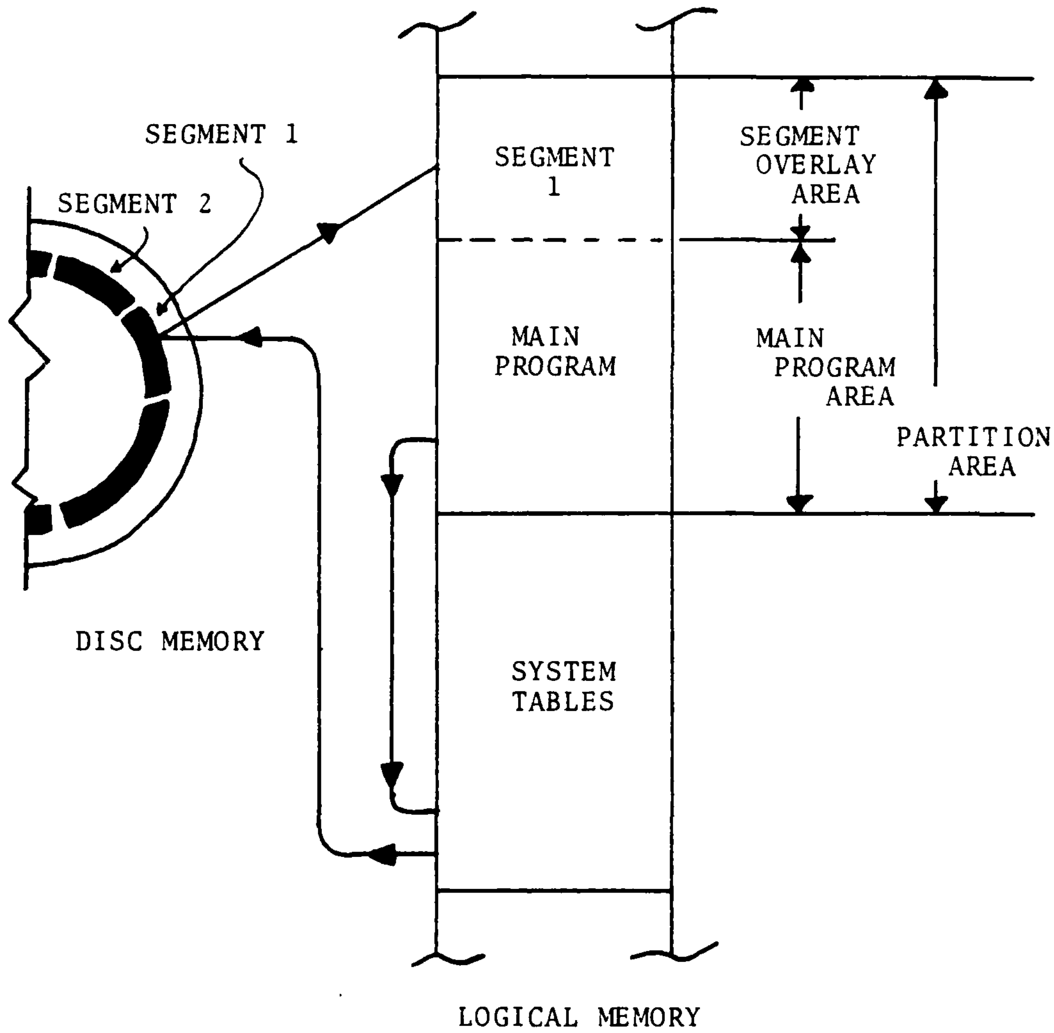

FIGURE C-1: PROGRAM SEGMENTATION-ILLUSTRATION OF THE MAIN PROGRAM CALLING A SEGMENT INTO LOGICAL MEMORY

APPENDIX: D

RUNNING THE COMPUTER PROGRAM

If the reader is unfamiliar with the HP-1000 Computer System, references [11] and [12] should be consulted before attempting to run the program.

D-1. DATA INPUT

Using the editor, input the following data into segment "SHORT".

1. Turbine operating conditions: referring to Table A-III, type in appropriate data in lines 66 through 69 and 74 through 78.

2. Special input data/program control parameters: referring to Tables A-IV and A-V, type in appropriate data in lines 83 through 98.

3. Turbine geometry: referring to Tables A-1 and A-II, type in data for stator and rotor in lines 103 through 186.

D-2 COMPILING THE PROGRAM

1. To compile the main program type:

   :RU,FTN4,MAIN::25,-,-

2. Compile the first segment:

   :RU,FTN4,SHORT::25,-,-

3. Compile the second segment:

```
:RU,FTN4,PART2::25,-,-
```

4. Compile the final segment:

```
:RU,FTN4PART3::25,-,-
```

D-3. LOADING THE PROGRAM

Type

```
: RU, LOADR
```

Tap return key

Will display

```
LOADR:
```

Type

```
OP,LB
```

Will display

```
LOADR:
```

Type

```
:RE,%MAIN::25
```

Will display

```
LOADR:
```

Type

```
:RE,%SHORT::25
```

Will display

```
LOADR:
```

Type

```
:RE,%PART2::25
```

Will display

LOADR:

Type

:RE,%PART3::25

Will display

LOADR:

Type

:END

After the end statement, the loader will display that the program is ready for execution.

D-4 RUNNING THE PROGRAM

Type

: RUN, THESS

The program will be executed and no further action by the operator is required. The computed pressure ratio of each iteration of the outer loop of the program is displayed on the screen as it is calculated. The operator therefore has some idea where in the iteration process the computer program is executing.

APPENDIX: E

DISCREPANCIES IN MACCHI'S PROGRAM

1. Main program, lines 21 and 22; the value of ICL has not yet been read.

2. Main program, lines 163-166; the Traupel method of calculating gas outlet angles does not take the Mach number into consideration. However, in lines 163-164, the program is attempting to draw a parabola through points which represent outlet angle as a function of Mach number.

3. Main program line 281; the calling of subroutine SLINE is questionable. Parameters are transferred to that subroutine, but many of them have not yet been defined (HE, DHEDX, WPER2, DSDX1). These undefined variables will be set equal to zero by the IBM 360 and 370 computers. Thus, in line 10 of subroutine SLINE, the value of DWDX will be zero and in line 17, division by zero will occur and the execution of the program should cease.

4. Subroutine ROTORI lines 22 and 26; the stator radii are used in the calculation whereas the rotor radii should be used.

5. Subroutine ASOSI, line 107; the correct Fortran code is

```
ZETAPS(I)  = .5 * ZETAS(I)
```

6. Subroutine ALOS2, line 121; the correct Fortran code is

```
ZETAPR(I) = .5 * ZETAPR(I)
```

7. Subroutine ALOS2, lines 123-126; the stator radii are used in the calculation whereas the rotor radii should be used.

8. Subroutine ANGAIN, line 14; the correct Fortran code is

```
AO = ATAN(1. -XCL/H*CH*COS(ANG1)/COS(ANG2)*
     TAN(ANG2) + XCL/H*CL*COS(ANG1)/COS(ANG2)*
     TAN(ANG1)
```

Note: Since reference [2] was published, Professor Macchi's program has been further developed by Professor Macchi under private sponsorship [Ref. 13]. The new code however, is not generally available.

APPENDIX F

COMPUTER OUTPUT

INPUT PRINTS

R1	A1	R2	A2
2.764	.2126	2.693	.1912
2.860	.2215	2.820	.2030
2.956	.2303	2.947	.2149
3.052	.2393	3.074	.2269
3.148	.2481	3.201	.2388
3.243	.2570	3.329	.2506
3.339	.2660	3.456	.2625
3.435	.2749	3.583	.2745
3.531	.2837	3.710	.2864
3.627	.2926	3.837	.2983

NUMBER OF STATOR BLADES = 31.
NUMBER OF ROTOR BLADES = 32.
ROTOR TIP CLEARANCE = .0100
AXIAL DISTANCE L = .88
CURVATURE FACTOR K = 5.00

BLADING GEOMETRY

	C	E	T	TE	TN	AL	R
STATOR	1.0030	2.8065	.2252	.0300	.0186	1.0880	2.7640
	1.0030	2.8065	.2252	.0300	.0186	1.0880	3.1955
	1.0030	2.8065	.2252	.0300	.0186	1.0880	3.6270
ROTOR	1.0030	2.4500	.2252	.0300	.0186	1.0880	2.6930
	1.0030	2.4500	.2252	.0300	.0186	1.0880	3.2650
	1.0030	2.4500	.2252	.0300	.0186	1.0880	3.8370

ALL DIMENSIONS INDICATED IN THIS TABLE ARE IN INCHES

CORRELATION SYSTEM
ICOR = 4
IAI = 0
IAN = 2
ICOZ = 6
IINC = 1
ICL = 0
ICON = 3

GAS PROPERTIES	CP (BTU/LB F)	MOLECULAR MASS	GAMM	VISCOSITY (1) (LBM /SEC FT)	VISCOSITY (2) (LBM /SEC FT)
	.240	28.970	1.400	.130E-04	.120E-04

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	5000.0	1.400	20.580	545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1015	.8980	.1020	.1020	0.0000
2	3.003	.940	0.0000	.2347	1.0468	.8935	.1065	.1065	.2581
3	3.195	1.000	.0290	.2526	1.0000	.8099	.1101	.1101	.4790
4	3.432	1.074	0.0000	.2745	.9407	.8871	.1129	.1129	.7609
5	3.627	1.135	0.0000	.2926	.8916	.8847	.1153	.1153	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	332.90	-13.35	735.38	807.33	332.90	-13.35	614.78	699.25	120.60
2	316.36	3.01	691.09	760.06	316.36	3.01	560.05	643.23	131.03
3	295.48	6.91	654.34	720.80	295.48	6.91	514.91	593.71	139.43
4	284.29	24.69	610.59	673.98	284.29	24.69	460.86	542.05	149.73
5	269.47	31.97	574.92	635.75	269.47	31.97	416.67	497.24	158.26

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.74	.64	65.65	61.57	545.50	491.26	19.691	13.648	1.0452	1.5079
2	.70	.59	65.41	60.54	545.50	497.43	19.762	14.309	1.0414	1.4382
3	.66	.54	65.21	60.16	545.50	502.27	19.823	14.848	1.0382	1.3851
4	.61	.49	65.04	58.33	545.50	507.70	19.905	15.482	1.0349	1.3273
5	.57	.45	64.89	57.11	545.50	511.87	19.970	15.983	1.0305	1.2876

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	5000.0	1.400	20.580	545.50

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9734	.7689	.2311	.2311	0.0000
2	3.020	.925	-.0168	.2218	.9964	.7681	.2320	.2320	.2418
3	3.265	1.000	-.0405	.2447	1.0000	.7674	.2326	.2326	.4446
4	3.595	1.098	-.1537	.2747	1.0392	.7711	.2289	.2289	.7358
5	3.837	1.175	-.2100	.2983	1.0911	.7740	.2260	.2260	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	214.82	-8.62	-399.46	453.64	214.82	-8.62	-516.96	559.89	117.58
2	219.89	2.09	-373.35	433.29	219.89	2.09	-505.11	550.90	131.77
3	220.69	5.05	-342.58	411.76	220.69	5.05	-490.05	537.47	142.46
4	229.35	19.92	-323.13	396.75	229.35	19.92	-479.57	531.96	156.44
5	240.79	28.57	-313.63	396.43	240.79	28.57	-401.05	538.71	167.42

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.41	.51	-61.73	-67.44	522.93	505.80	16.080	14.311	1.2799	1.4381
2	.39	.50	-59.51	-66.48	522.24	506.62	16.090	14.467	1.2791	1.4226
3	.37	.49	-57.59	-65.76	522.08	507.63	16.162	14.650	1.2734	1.4044
4	.36	.48	-54.64	-64.45	521.87	508.77	16.242	14.859	1.2671	1.385
5	.36	.49	-52.49	-63.41	521.62	508.54	15.250	14.877	1.2657	1.3833

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	531.89	18.024	1.3
2	531.87	18.088	1.3
3	531.67	18.119	1.2
4	532.32	18.272	1.2
5	532.69	18.376	1.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	5800.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT OT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.4381	1.2799	.4197	.6079	44.4345	.1500	-.1231
2	1.4225	1.2791	.4451	.6279	36.5720	.1654	-.0296
3	1.4048	1.2734	.4640	.6436	31.2045	.1790	.0376
4	1.3858	1.2671	.4875	.6623	25.9882	.1962	.1209
5	1.3833	1.2657	.4944	.6724	23.1752	.2077	.2130

MASS AVERAGED QUANTITIES

HORSE POWER =	20.27	(HP)
MOMENT =	21.29	(FT-LB)
FLOW RATE =	2.55	(LB/SEC)
REFERRED RPM =	4874.22	
REFERRED HORSE POWER =	14.12	(HP)
REFERRED MOMENT =	15.21	(FT-LB)
REFERRED FLOW RATE =	1.87	(LB/SEC)
TOTAL/STATIC EFFICIENCY =	.4634	
TOTAL/TOTAL EFFICIENCY=	.6435	
TOTAL/STATIC PRESSURE RATIO =	1.4058	
TOTAL/TOTAL PRESSURE RATIO =	1.2731	
HEAD COEFFICIENT =	31.8904	
BLADE/JET SPEED RATIO =	.1771	
THEORETICAL DEGREE OF REACTION=	.0435	
MACH NUMBER AT STATION 0 =	.1856	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	10000.0	1.400	20.580	545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0991	.8889	.1111	.1111	0.0000
2	3.003	.940	0.0000	.2347	1.0455	.8856	.1144	.1144	.2602
3	3.195	1.000	.0290	.2526	1.0000	.8829	.1171	.1171	.4813
4	3.432	1.074	0.0000	.2745	.9430	.8852	.1148	.1148	.7624
5	3.627	1.135	0.0000	.2926	.8960	.8872	.1128	.1128	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	291.65	-11.70	644.27	707.30	291.65	-11.70	403.06	497.65	241.21
2	277.43	2.64	606.06	666.55	277.43	2.64	343.99	441.93	262.07
3	265.36	6.07	574.53	632.89	265.36	6.07	295.67	397.34	278.86
4	250.25	21.73	537.47	593.27	250.25	21.73	238.00	346.03	299.47
5	237.78	28.21	507.31	560.98	237.78	28.21	190.79	306.16	316.52

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.64	.45	65.65	54.12	545.50	503.87	19.846	15.032	1.0370	1.3691
2	.60	.40	65.41	51.12	545.50	508.53	19.911	15.575	1.0336	1.3214
3	.57	.36	65.21	48.10	545.50	512.17	19.965	16.012	1.0308	1.2853
4	.53	.31	65.04	43.57	545.50	516.21	20.055	16.533	1.0262	1.2448
5	.50	.27	64.89	38.75	545.50	519.31	20.122	16.939	1.0228	1.2149

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	10000.0	1.400	20.580	545.50

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA8 CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9837	.8286	.1715	.1715	0.0000
2	3.020	.925	-.0168	.2218	.9556	.8373	.1628	.1628	.2340
3	3.265	1.000	-.0405	.2447	1.0000	.8438	.1563	.1563	.4308
4	3.585	1.098	-.1537	.2747	1.0916	.8515	.1485	.1485	.7242
5	3.837	1.175	-.2100	.2983	1.1071	.8576	.1425	.1425	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	201.32	-8.08	-249.46	320.66	201.32	-8.08	-404.47	524.70	245.01
2	195.57	1.86	-185.71	269.70	195.57	1.86	-449.25	489.97	263.54
3	204.66	4.68	-169.51	265.78	204.66	4.68	-454.44	498.42	284.93
4	223.41	19.40	-154.28	272.20	223.41	19.40	-457.17	518.20	312.88
5	242.95	28.82	-150.52	287.25	242.95	28.82	-485.36	543.54	334.84

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.29	.48	-51.10	-67.44	509.88	501.32	15.156	14.284	1.3579	1.4407
2	.24	.44	-43.52	-66.48	510.92	504.87	15.411	14.781	1.3355	1.3923
3	.24	.45	-39.54	-65.76	510.80	504.92	15.445	14.832	1.3325	1.3876
4	.25	.47	-34.63	-64.45	510.68	504.51	15.494	14.849	1.3282	1.3859
5	.26	.49	-31.78	-63.41	510.39	503.52	15.494	14.777	1.3283	1.3927

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	524.23	17.267	1.2
2	524.85	17.395	1.2
3	525.59	17.529	1.2
4	526.86	17.757	1.2
5	528.11	17.964	1.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.4407	1.3579	.6591	.7802	11.1627	.2993	.1334
2	1.3923	1.3355	.7025	.7991	8.6122	.3408	.1518
3	1.3876	1.3325	.7121	.8080	7.5311	.3644	.2253
4	1.3859	1.3282	.7170	.8195	6.5076	.3920	.3187
5	1.3927	1.3283	.7128	.8263	5.7890	.4114	.4008

MASS AVERAGED QUANTITIES

HORSE POWER = 28.96 (HP)
MOMENT = 15.21 (FT-LB)
FLOW RATE = 2.45 (LB/SEC)

REFERRED RPM = 9748.44
REFERRED HORSE POWER = 20.17 (HP)
REFERRED MOMENT = 10.86 (FT-LB)
REFERRED FLOW RATE = 1.79 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7044
TOTAL/TOTAL EFFICIENCY= .8075
TOTAL/STATIC PRESSURE RATIO = 1.3956
TOTAL/TOTAL PRESSURE RATIO = 1.3348

HEAD COEFFICIENT = 7.7967
BLADE/JET SPEED RATIO = .3581
THEORETICAL DEGREE OF REACTION= .2407
MACH NUMBER AT STATION 0 = .1777

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	15000.0	1.400	20.580	545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0977	.8955	.1045	.1045	0.0000
2	3.003	.940	0.0000	.2347	1.0453	.8953	.1047	.1047	.2610
3	3.195	1.000	.0290	.2526	1.0000	.8952	.1048	.1048	.4826
4	3.432	1.074	0.0000	.2745	.9416	.8948	.1052	.1052	.7635
5	3.627	1.135	0.0000	.2926	.8928	.8945	.1055	.1055	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	279.79	-11.22	618.08	678.55	279.79	-11.22	256.27	379.59	361.81
2	266.45	2.53	582.07	640.16	266.45	2.53	188.97	326.67	393.10
3	254.90	5.83	551.88	607.93	254.90	5.83	133.59	287.84	418.29
4	240.00	20.84	515.46	568.98	240.00	20.84	66.26	249.85	449.20
5	227.58	27.00	485.56	536.93	227.58	27.00	10.79	229.43	474.77

STREAM LINE	MACH NUMBER ABSOLUTE	MACH NUMBER RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	FLOW ANGLE (DEG) RELATIVE	TEMPERATURE (DEG. R) TOTAL	TEMPERATURE (DEG. R) STATIC	PRESSURE (PSI) TOTAL	PRESSURE (PSI) STATIC	PRESSURE RATIO TOT/TOT	PRESSURE RATIO TOT/STA
1	.61	.34	65.65	42.49	545.50	507.19	19.952	15.463	1.0315	1.3309
2	.58	.29	65.41	35.35	545.50	511.40	20.024	15.975	1.0278	1.2883
3	.55	.26	65.21	27.66	545.50	514.75	20.081	16.390	1.0249	1.2557
4	.51	.22	65.04	15.43	545.50	518.56	20.144	16.872	1.0217	1.2198
5	.48	.20	64.89	2.71	545.50	521.51	20.192	17.251	1.0192	1.1930

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	15000.0	1.400	20.580	545.50

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9944	.8722	.1279	.1279	0.0000
2	3.020	.925	-.0168	.2218	.9132	.8785	.1216	.1216	.2253
3	3.265	1.000	-.0405	.2447	1.0000	.8832	.1169	.1169	.4152
4	3.585	1.098	-.1537	.2747	1.1537	.8737	.1263	.1263	.7112
5	3.837	1.175	-.2100	.2983	1.3031	.8663	.1337	.1337	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	192.13	-7.71	-109.84	221.44	192.13	-7.71	-462.35	500.74	352.51
2	176.44	1.68	-10.00	176.73	176.44	1.68	-405.30	442.05	395.31
3	193.21	4.42	-1.64	193.27	193.21	4.42	-429.03	470.55	427.39
4	222.92	19.36	3.20	223.78	222.92	19.36	-466.13	517.05	469.33
5	251.77	29.87	-.72	253.54	251.77	29.87	-502.98	563.27	502.26

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.20	.46	-29.76	-67.44	501.84	497.76	14.582	14.171	1.4113	1.4523
2	.16	.40	-3.24	-66.48	506.76	504.16	15.233	14.961	1.3510	1.3756
3	.18	.43	-.49	-65.76	506.97	503.86	15.277	14.952	1.3471	1.3764
4	.20	.47	.82	-64.45	507.21	503.05	15.268	14.833	1.3479	1.3874
5	.23	.51	-.16	-63.41	507.07	501.72	15.197	14.643	1.3542	1.4054

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	518.62	16.718	1.2
2	520.42	16.983	1.1
3	522.28	17.245	1.2
4	525.29	17.651	1.2
5	528.13	18.029	1.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	TOT/TOT	EFFICIENCY TOT/STA	TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.4523	1.4113	.7916	.8538	5.0637	.4444	.2243
2	1.3756	1.3510	.8156	.8622	3.6937	.5203	.1981
3	1.3764	1.3471	.8098	.8657	3.2684	.5531	.2781
4	1.3874	1.3479	.7859	.8584	2.9014	.5871	.3821
5	1.4054	1.3542	.7602	.8488	2.6948	.6092	.4694

MASS AVERAGED QUANTITIES

HORSE POWER	=	31.71	(HP)
MOMENT	=	11.10	(FT-LB)
FLOW RATE	=	2.39	(LB/SEC)
REFERRED RPM	=	14622.66	
REFERRED HORSE POWER	=	22.08	(HP)
REFERRED MOMENT	=	7.93	(FT-LB)
REFERRED FLOW RATE	=	1.75	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7968	
TOTAL/TOTAL EFFICIENCY	=	.8594	
TOTAL/STATIC PRESSURE RATIO	=	1.3921	
TOTAL/TOTAL PRESSURE RATIO	=	1.3572	
HEAD COEFFICIENT	=	3.4357	
BLADE/JET SPEED RATIO	=	.5395	
THEORETICAL DEGREE OF REACTION	=	.3013	
MACH NUMBER AT STATION 0	=	.1735	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	1.400	20.580	545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1027	.9123	.0877	.0877	0.0000
2	3.003	.940	0.0000	.2347	1.0473	.9091	.0909	.0909	.2613
3	3.195	1.000	.0290	.2526	1.0000	.9065	.0935	.0935	.4829
4	3.432	1.074	0.0000	.2745	.9400	.9051	.0949	.0949	.7637
5	3.627	1.135	0.0000	.2926	.8903	.9040	.0960	.0960	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHIRL VELOCITY
1	291.10	-11.68	643.86	705.98	291.10	-11.68	160.65	332.69	482.41
2	276.49	2.63	604.00	664.29	276.49	2.63	79.86	287.81	524.14
3	241.95	6.04	571.59	629.64	241.95	6.04	13.87	242.42	557.72
4	245.16	21.55	532.98	588.31	248.16	21.55	-65.96	257.68	598.94
5	235.05	27.89	501.49	554.54	235.05	27.89	-131.54	270.79	633.03

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.64	.30	65.65	28.89	545.50	504.03	20.016	15.177	1.0282	1.3560
2	.60	.26	65.41	16.11	545.50	508.78	20.065	15.722	1.0257	1.3070
3	.57	.22	65.21	3.28	545.50	512.51	20.106	16.162	1.0236	1.2733
4	.53	.23	65.04	-14.89	545.50	516.70	20.162	16.676	1.0207	1.2341
5	.50	.24	64.89	-29.24	545.50	519.91	20.206	17.079	1.0185	1.2050

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	1.400	20.580	545.50

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0076	.8915	.1085	.1085	0.0000
2	3.020	.925	-.0168	.2218	.8705	.8756	.1244	.1244	.2140
3	3.265	1.000	-.0405	.2447	1.0000	.8637	.1364	.1364	.3939
4	3.585	1.098	-.1537	.2747	1.2350	.8696	.1304	.1304	.6917
5	3.837	1.175	-.2100	.2983	1.4565	.8743	.1258	.1258	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	178.28	-7.15	40.98	183.07	178.28	-7.15	-429.04	464.66	470.02
2	154.03	1.46	173.25	231.82	154.03	1.46	-353.82	385.90	527.07
3	176.94	4.05	176.95	250.27	176.94	4.05	-392.90	430.92	569.85
4	218.53	18.98	168.82	276.79	218.53	18.98	-456.95	506.87	625.77
5	257.72	30.58	154.81	302.20	257.72	30.58	-514.88	576.59	669.68

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.17	.43	12.95	-67.44	497.08	494.29	14.234	13.957	1.4458	1.4745
2	.21	.35	48.36	-66.48	508.01	503.54	15.448	14.978	1.3322	1.3741
3	.23	.39	45.00	-65.76	509.23	503.09	15.536	14.890	1.3247	1.3821
4	.25	.46	37.69	-64.45	509.96	503.58	15.574	14.903	1.3214	1.3809
5	.28	.52	30.99	-63.41	509.92	502.32	15.519	14.725	1.3261	1.3977

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	512.26	16.062	1.2
2	515.93	16.509	1.1
3	518.54	16.837	1.1
4	524.96	17.628	1.2
5	529.99	18.265	1.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	TOT/TOT	EFFICIENCY TOT/STA	TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.4745	1.4458	.8453	.8880	2.9583	.5814	.2065
2	1.3241	1.3322	.7919	.8735	2.0709	.6949	.1468
3	1.3821	1.3247	.7529	.8615	1.8612	.7330	.2446
4	1.3889	1.3214	.7398	.8514	1.6096	.7882	.3378
5	1.3977	1.3261	.7150	.8419	1.4923	.8186	.4311

MASS AVERAGED QUANTITIES

HORSE POWER	=	28.63	(HP)
MOMENT	=	7.52	(FT-LB)
FLOW RATE	=	2.25	(LB/SEC)
REFERRED RPM	=	19496.88	
REFERRED HORSE POWER	=	19.94	(HP)
REFERRED MOMENT	=	5.37	(FT-LB)
REFERRED FLOW RATE	=	1.65	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7662	
TOTAL/TOTAL EFFICIENCY	=	.8628	
TOTAL/STATIC PRESSURE RATIO	=	1.3933	
TOTAL/TOTAL PRESSURE RATIO	=	1.3411	
HEAD COEFFICIENT	=	1.9418	
BLADE/JET SPEED RATIO	=	.7176	
THEORETICAL DEGREE OF REACTION	=	.2620	
MACH NUMBER AT STATION 0	=	.1629	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	25000.0	1.400	20.580	545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1005	.9045	.0955	.0955	0.0000
2	3.003	.940	0.0000	.2347	1.0465	.9026	.0974	.0974	.2612
3	3.195	1.000	.0290	.2526	1.0000	.9011	.0989	.0989	.4829
4	3.432	1.074	0.0000	.2745	.9405	.8997	.1003	.1003	.7637
5	3.627	1.135	0.0000	.2926	.8912	.8986	.1014	.1014	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	285.88	-11.47	631.53	693.32	285.88	-11.47	28.52	287.53	603.01
2	271.85	2.58	593.87	653.14	271.85	2.58	-61.31	278.69	655.17
3	263.01	5.94	562.45	619.58	263.01	5.94	-134.70	295.56	697.15
4	244.34	21.22	524.77	579.25	244.34	21.22	-223.90	332.09	748.67
5	231.51	27.47	493.94	546.20	231.51	27.47	-297.35	377.85	791.29

STREAM LINE	MACH NUMBER ABSOLUTE	MACH NUMBER RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	FLOW ANGLE (DEG) RELATIVE	TEMPERATURE (DEG. R) TOTAL	TEMPERATURE (DEG. R) STATIC	PRESSURE (PSI) TOTAL	PRESSURE (PSI) STATIC	PRESSURE RATIO TOT/TOT	PRESSURE RATIO TOT/STA
1	.63	.26	65.65	5.70	545.50	505.50	19.985	15.309	1.0298	1.3443
2	.59	.25	65.41	-12.71	545.50	510.00	20.044	15.838	1.0267	1.2994
3	.56	.27	65.21	-27.12	545.50	513.56	20.092	16.267	1.0243	1.2651
4	.52	.30	65.04	-42.50	545.50	517.58	20.150	16.766	1.0213	1.2275
5	.49	.34	64.89	-52.10	545.50	520.68	20.195	17.157	1.0191	1.1995

SET NUMBER	STAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	25000.0	1.400	20.580	545.50

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA# CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0181	.8812	.1189	.1189	0.0000
2	3.020	.925	-.0168	.2218	.8317	.8756	.1245	.1245	.2053
3	3.265	1.000	-.0405	.2447	1.0000	.8714	.1287	.1287	.3807
4	3.585	1.098	-.1537	.2747	1.2682	.8796	.1205	.1205	.6822
5	3.837	1.175	-.2100	.2983	1.5106	.8861	.1140	.1140	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	193.70	-7.77	121.38	228.72	193.70	-7.77	-466.14	504.85	587.52
2	158.25	1.50	295.33	335.06	158.25	1.50	-363.52	396.47	658.84
3	190.26	4.35	289.84	346.74	190.26	4.35	-422.47	463.36	712.31
4	241.28	20.96	277.69	368.46	241.28	20.96	-504.53	559.64	782.21
5	287.40	34.10	262.93	391.02	287.40	34.10	-574.17	642.99	837.11

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.21	.47	32.07	-67.44	493.99	489.64	13.836	13.414	1.4874	1.5342
2	.30	.36	61.82	-66.48	513.13	503.79	15.973	14.978	1.2885	1.3740
3	.31	.42	56.72	-65.76	514.60	504.74	16.086	15.032	1.2794	1.3691
4	.33	.51	49.02	-64.45	516.26	504.97	16.209	15.001	1.2696	1.3719
5	.36	.58	42.46	-63.41	517.08	504.36	16.238	14.882	1.2674	1.3829

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	510.85	15.883	1.2
2	516.87	16.597	1.1
3	522.60	17.292	1.2
4	531.03	18.340	1.2
5	538.76	19.336	1.3

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.5342	1.4874	.8204	.8806	2.0751	.6942	.2957
2	1.3748	1.2885	.6838	.8496	1.3263	.8686	.1693
3	1.3491	1.2794	.6598	.8332	1.1528	.9294	.2430
4	1.3719	1.2696	.6205	.8129	1.0102	.9950	.3414
5	1.3829	1.2674	.5889	.7957	.9261	1.0391	.4275

MASS AVERAGED QUANTITIES

HORSE POWER	=	26.78	(HP)
MOMENT	=	5.63	(FT-LB)
FLOW RATE	=	2.43	(LB/SEC)
REFERRED RPM	=	24371.10	
REFERRED HORSE POWER	=	18.64	(HP)
REFERRED MOMENT	=	4.02	(FT-LB)
REFERRED FLOW RATE	=	1.78	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.6672	
TOTAL/TOTAL EFFICIENCY	=	.8335	
TOTAL/STATIC PRESSURE RATIO	=	1.3934	
TOTAL/TOTAL PRESSURE RATIO	=	1.3037	
HEAD COEFFICIENT	=	1.2485	
BLADE/JET SPEED RATIO	=	.8950	
THEORETICAL DEGREE OF REACTION	=	.2788	
MACH NUMBER AT STATION 0	=	.1768	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	30000.0	1.400	20.580	545.50

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA./VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	Z, TA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1012	.9078	.0922	.0922	0.0000
2	3.003	.940	0.0000	.2347	1.0468	.9055	.0945	.0945	.2601
3	3.195	1.000	.0290	.2526	1.0000	.9036	.0964	.0964	.4815
4	3.432	1.074	0.0000	.2745	.9403	.9019	.0981	.0981	.7628
5	3.627	1.135	0.0000	.2926	.8907	.9006	.0994	.0994	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	305.04	-12.24	673.85	739.78	305.04	-12.24	-49.77	309.32	723.62
2	289.96	2.75	633.43	696.65	289.96	2.75	-152.78	327.76	766.21
3	280.02	6.34	599.75	660.66	280.02	6.34	-236.83	366.80	836.58
4	260.46	22.62	559.41	617.48	260.46	22.62	-339.00	428.11	898.41
5	246.73	29.27	526.42	582.11	246.73	29.27	-423.13	490.68	949.55

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.67	.28	65.65	-9.27	545.50	499.96	19.921	14.683	1.0331	1.4036
2	.63	.30	65.41	-27.79	545.50	505.12	19.985	15.268	1.0298	1.3479
3	.60	.33	65.21	-40.23	545.50	509.18	20.037	15.743	1.0271	1.3072
4	.56	.39	65.04	-52.47	545.50	513.77	20.100	16.298	1.0239	1.2628
5	.52	.44	64.89	-59.76	545.50	517.30	20.150	16.734	1.0213	1.2298

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	30000.0	1.400	20.580	545.50

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0718	.1912	1.0274	.8819	.1181	.1181	0.0000
2	3.020	.925	-.0168	.2218	.7995	.8792	.1208	.1208	.1951
3	3.265	1.000	-.0405	.2447	1.0000	.8772	.1228	.1228	.3644
4	3.585	1.098	-.1537	.2747	1.3181	.8871	.1130	.1130	.6688
5	3.837	1.175	-.2100	.2983	1.6051	.8948	.1052	.1052	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	200.40	-8.04	222.75	299.74	200.40	-8.04	-482.28	522.32	705.03
2	155.94	1.48	432.40	459.66	155.94	1.48	-358.21	390.68	790.61
3	195.05	4.46	421.66	464.61	195.05	4.46	-433.11	475.03	854.78
4	257.10	22.33	401.05	476.91	257.10	22.33	-537.60	596.34	938.65
5	313.08	37.15	379.05	493.03	313.08	37.15	-625.47	700.44	1004.53

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATI	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.28	.48	48.03	-67.44	490.49	483.81	13.432	12.729	1.5322	1.6168
2	.42	.36	70.17	-66.48	519.51	501.93	16.642	14.753	1.2366	1.3950
3	.42	.43	65.18	-65.76	521.98	504.16	16.862	14.931	1.2205	1.3783
4	.43	.54	57.34	-64.45	524.51	505.58	17.068	15.008	1.2058	1.3713
5	.45	.64	50.45	-63.41	525.68	505.45	17.120	14.923	1.2021	1.3791

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	505.71	15.283	1.2
2	514.63	16.299	1.1
3	522.94	17.283	1.2
4	535.18	18.800	1.3
5	546.28	20.251	1.4

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	1.400	20.580	545.50

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.6168	1.5322	.7863	.8787	1.6058	.7891	.2830
2	1.3950	1.2366	.5251	.8092	.9621	1.0195	.0987
3	1.3703	1.2205	.4922	.7790	.8205	1.1040	.1588
4	1.3713	1.2058	.4461	.7392	.7806	1.1947	.2524
5	1.3791	1.2021	.4141	.7092	.6379	1.2521	.3458

MASS AVERAGED QUANTITIES

HORSE POWER = 22.02 (HP)
MOMENT = 3.86 (FT-LB)
FLOW RATE = 2.53 (LB/SEC)

REFERRED RPM = 29245.32
REFERRED HORSE POWER = 15.33 (HP)
REFERRED MOMENT = 2.75 (FT-LB)
REFERRED FLOW RATE = 1.85 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .5159
TOTAL/TOTAL EFFICIENCY= .7803
TOTAL/STATIC PRESSURE RATIO = 1.4106
TOTAL/TOTAL PRESSURE RATIO = 1.2575

HEAD COEFFICIENT = .9013
BLADE/JET SPEED RATIO = 1.0534
THEORETICAL DEGREE OF REACTION= .2061
MACH NUMBER AT STATION 0 = .1841

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	5000.0	1.600	23.520	562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1046	.9106	.0894	.0894	0.0000
2	3.003	.940	0.0000	.2347	1.0480	.9041	.0959	.0959	.2535
3	3.195	1.000	.0290	.2526	1.0000	.8988	.1012	.1012	.4729
4	3.432	1.074	0.0000	.2745	.9395	.8946	.1054	.1054	.7568
5	3.627	1.135	0.0000	.2926	.8898	.8912	.1088	.1088	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	402.80	-16.16	889.81	976.87	402.80	-16.16	769.21	868.44	120.60
2	382.17	3.63	834.86	918.19	382.17	3.63	703.83	800.90	131.03
3	358.89	8.34	789.52	869.70	358.89	8.34	650.00	742.62	[illegible]
4	342.61	29.76	735.84	812.24	342.61	29.76	586.11	679.55	[illegible]
5	324.46	38.49	692.24	765.48	324.46	38.49	543.98	626.01	[illegible]

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.91	.81	65.65	62.37	562.23	482.82	22.218	13.039	1.0586	[illegible]
2	.84	.74	65.41	61.50	562.23	492.03	22.298	13.916	[illegible]	[illegible]
3	.79	.68	65.21	61.10	562.23	499.79	22.372	14.765	[illegible]	[illegible]
4	.74	.62	65.04	59.70	562.23	507.33	22.488	15.675	1.0459	[illegible]
5	.69	.56	64.89	58.72	562.23	513.47	22.580	16.437	1.0416	[illegible]

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	5000.0	1.600	23.520	562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9722	.7663	.2337	.2337	0.0000
2	3.020	.925	-.0168	.2218	1.0017	.7642	.2353	.2353	.2414
3	3.265	1.000	-.0405	.2447	1.0000	.7635	.2365	.2365	.4445
4	3.585	1.098	-.1537	.2747	1.0302	.7654	.2346	.2346	.7362
5	3.837	1.175	-.2100	.2983	1.0743	.7669	.2331	.2331	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	260.85	-10.46	-510.24	573.15	260.85	-10.46	-622.75	679.87	117.50
2	268.76	2.55	-485.60	555.02	268.76	2.55	-617.37	673.34	131.77
3	268.30	6.14	-453.30	526.79	268.30	6.14	-595.76	653.42	[illegible]
4	276.42	24.01	-421.56	504.68	276.42	24.01	-578.00	641.15	[illegible]
5	288.24	34.20	-408.42	501.06	288.24	34.20	-575.84	644.86	167.42

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.52	.62	-62.93	-67.44	534.39	507.06	17.137	14.260	1.3725	1.6494
2	.50	.61	-61.04	-66.48	533.37	507.74	17.101	14.393	1.3751	1.6741
3	.48	.59	-59.38	-65.76	533.16	509.72	17.212	14.706	1.3645	1.5593
4	.46	.58	-56.75	-64.45	532.92	511.72	17.342	15.045	1.3563	1.5633
5	.45	.58	-54.79	-63.41	532.62	511.73	17.374	15.104	1.3537	1.5572

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	545.52	19.991	1.4
2	545.47	20.057	1.4
3	545.25	20.095	1.4
4	545.93	20.282	1.3
5	546.33	20.423	1.4

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	5000.0	1.600	23.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.6494	1.3725	.3717	.5735	61.8818	.1271	-.1643
2	1.6341	1.3754	.3921	.5897	51.5135	.1393	-.0543
3	1.5993	1.3665	.4118	.6058	43.6353	.1514	.0077
4	1.5633	1.3563	.4351	.6253	36.1130	.1664	.0892
5	1.5572	1.3537	.4431	.6354	32.0649	.1766	.1813

MASS AVERAGED QUANTITIES

HORSE POWER = 30.55 (HP)
MOMENT = 32.09 (FT-LB)
FLOW RATE = 3.10 (LB/SEC)

REFERRED RPM = 4801.15
REFERRED HORSE POWER = 18.33 (HP)
REFERRED MOMENT = 20.06 (FT-LB)
REFERRED FLOW RATE = 2.02 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .4116
TOTAL/TOTAL EFFICIENCY = .6062
TOTAL/STATIC PRESSURE RATIO = 1.6000
TOTAL/TOTAL PRESSURE RATIO = 1.3653

HEAD COEFFICIENT = 44.5558
BLADE/JET SPEED RATIO = .1498
THEORETICAL DEGREE OF REACTION = .0128
MACH NUMBER AT STATION 0 = .2011

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	10000.0	1.600	23.520	562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1044	.9084	.0916	.0916	0.0000
2	3.003	.940	0.0000	.2347	1.0479	.9019	.0981	.0981	.2562
3	3.195	1.000	.0290	.2526	1.0000	.8968	.1032	.1032	.4765
4	3.432	1.074	0.0000	.2745	.9397	.8931	.1069	.1069	.7591
5	3.627	1.135	0.0000	.2926	.8901	.8901	.1099	.1099	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	371.28	-14.89	820.18	900.42	371.28	-14.89	578.97	687.95	241.21
2	352.29	3.35	769.58	846.39	352.29	3.35	507.51	617.81	[illegible].07
3	320.09	7.69	727.85	801.77	320.09	7.69	448.99	551.46	278.86
4	315.91	27.44	628.50	748.94	315.91	27.44	379.05	494.19	[illegible].47
5	299.23	35.50	638.43	705.97	299.23	35.50	321.91	440.94	316.52

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.83	.63	65.65	57.33	562.23	494.77	22.407	14.325	1.0497	1.6419
2	.77	.56	65.41	55.24	562.23	502.62	22.475	15.133	1.0465	1.5491
3	.73	.50	65.21	54.52	562.23	508.74	22.538	15.884	1.0435	1.4807
4	.67	.44	65.04	50.19	562.23	515.55	22.640	16.716	1.0389	1.4070
5	.63	.39	64.89	47.09	562.23	520.76	22.720	17.376	1.0[illegible]	1.3536

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	10000.0	1.600	23.520	562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9799	.8166	.1834	.1834	0.0000
2	3.020	.925	-.0168	.2218	.9715	.8199	.1802	.1802	.2360
3	3.265	1.000	-.0405	.2447	1.0000	.8223	.1777	.1777	.4344
4	3.585	1.098	-.1537	.2747	1.0785	.8328	.1673	.1673	.7270
5	3.837	1.175	-.2100	.2983	1.1644	.8409	.1591	.1571	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	242.02	-9.71	-347.41	423.51	242.02	-9.71	-582.42	636.78	235.01
2	239.94	2.28	-287.63	374.58	239.94	2.28	-551.17	601.14	263.54
3	245.93	5.65	-263.49	361.19	246.98	5.65	-538.42	601.42	286.73
4	266.38	23.14	-244.13	362.07	266.38	23.14	-557.02	617.87	[illegible]
5	287.60	34.12	-239.71	375.95	287.60	34.12	-574.55	643.42	334.84

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.39	.58	-55.14	-67.44	515.72	500.79	15.718	14.182	1.4964	1.5584
2	.34	.55	-50.17	-66.48	516.05	504.37	15.899	14.675	1.4793	1.5687
3	.33	.55	-46.86	-65.76	515.96	504.22	15.945	14.712	1.4751	1.5937
4	.33	.56	-42.51	-64.45	515.70	504.79	16.004	14.850	1.4576	1.5835
5	.34	.58	-39.81	-63.41	515.24	503.48	15.994	14.752	1.4706	1.5744

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	533.90	18.698	1.3
2	534.44	18.822	1.3
3	533.33	18.861	1.3
4	546.56	19.224	1.3
5	537.93	19.465	1.3

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	1.609	23.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.6584	1.4964	.6148	.7605	15.6275	.2530	.0183
2	1.6027	1.4293	.6515	.7761	12.4023	.2840	.0675
3	1.5937	1.4751	.6560	.7830	10.9005	.3029	.1543
4	1.5838	1.4696	.6722	.7915	9.2752	.3284	.2450
5	1.5944	1.4706	.6698	.8010	8.4152	.3447	.3358

MASS AVERAGED QUANTITIES

HORSE POWER	=	46.17	(HP)
MOMENT	=	24.25	(FT-LB)
FLOW RATE	=	2.93	(LB/SEC)
REFERRED RPM	=	9602.30	
REFERRED HORSE POWER	=	27.71	(HP)
REFERRED MOMENT	=	15.16	(FT-LB)
REFERRED FLOW RATE	=	1.91	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.6555	
TOTAL/TOTAL EFFICIENCY	=	.7856	
TOTAL/STATIC PRESSURE RATIO	=	1.6029	
TOTAL/TOTAL PRESSURE RATIO	=	1.4759	
HEAD COEFFICIENT	=	11.1498	
BLADE/JET SPEED RATIO	=	.2995	
THEORETICAL DEGREE OF REACTION	=	.1710	
MACH NUMBER AT STATION 0	=	.1894	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	15000.0	1.600	23.520	562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0971	.8962	.1038	.1038	0.0000
2	3.003	.940	0.0000	.2347	1.0451	.8964	.1036	.1036	.2575
3	3.195	1.000	.0290	.2526	1.0000	.8965	.1035	.1035	.4784
4	3.432	1.074	0.0000	.2745	.9417	.8963	.1037	.1037	.7606
5	3.627	1.135	0.0000	.2926	.8931	.8961	.1039	.1039	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	332.10	-13.32	733.62	805.40	332.10	-13.32	371.82	498.71	361.81
2	316.36	3.01	691.08	760.06	316.36	3.01	297.98	[illegible]	[illegible]
3	307.42	6.93	655.37	721.93	307.42	6.93	232.08	[illegible]	[illegible]
4	285.06	24.76	612.23	675.79	285.06	24.76	163.02	[illegible]	449.20
5	270.33	32.07	576.77	637.79	270.33	32.07	102.00	[illegible]	474.77

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.73	.45	65.65	48.23	562.23	508.25	23.523	15.920	1.0443	[illegible]
2	.68	.39	65.41	43.29	562.23	514.16	22.642	16.560	[illegible]	[illegible]
3	.65	.35	65.21	32.64	562.23	516.86	22.735	17.165	[illegible]	[illegible]
4	.60	.29	65.04	29.77	562.23	524.23	22.936	17.825	[illegible]	[illegible]
5	.57	.26	64.89	20.67	562.23	528.38	22.914	18.438	[illegible]	[illegible]

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	15000.0	1.600	23.520	562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9084	.8631	.1370	.1370	0.0000
2	3.020	.925	-.0168	.2218	.9347	.8702	.1298	.1298	.2286
3	3.265	1.000	-.0405	.2447	1.0000	.8756	.1245	.1245	.4226
4	3.585	1.098	-.1532	.2747	1.1198	.8815	.1185	.1185	.7179
5	3.837	1.175	-.2100	.2983	1.2392	.8862	.1139	.1139	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	238.29	-9.56	-220.95	325.11	238.29	-9.56	-573.46	621.08	352.51
2	225.36	2.14	-122.38	256.45	225.36	2.14	-517.68	564.61	395.31
3	241.10	5.52	-107.98	264.24	241.10	5.52	-535.37	587.18	427.39
4	269.98	23.45	-95.22	287.24	269.98	23.45	-564.55	626.23	469.33
5	298.76	35.45	-94.60	315.38	298.76	35.45	-596.87	668.41	502.26

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.30	.57	-42.84	-67.44	505.09	496.30	14.930	14.039	1.5754	1.6753
2	.23	.51	-28.50	-66.48	508.97	503.49	15.547	14.969	1.5129	1.5712
3	.24	.53	-24.13	-65.76	508.93	503.36	15.593	15.004	1.5084	1.5676
4	.26	.57	-19.43	-64.45	509.02	502.16	15.638	14.912	1.5041	1.5773
5	.29	.61	-17.57	-63.41	508.75	500.47	15.616	14.245	1.5061	[illegible]

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	528.40	18.126	1.3
2	530.02	18.418	1.2
3	532.05	18.742	1.2
4	534.79	19.168	1.3
5	537.65	19.595	1.3

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	1.600	23.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.6253	1.5754	.7414	.8345	7.0747	.3760	.2185
2	1.5712	1.5129	.7822	.8492	5.2951	.4346	.2124
3	1.5676	1.5084	.7866	.8556	4.6545	.4635	.2061
4	1.5773	1.5041	.7752	.8598	4.0076	.4946	.3822
5	1.5951	1.5061	.7617	.8615	3.7435	.5168	.4620

MASS AVERAGED QUANTITIES

HORSE POWER	=	54.17	(HP)
MOMENT	=	18.97	(FT-LB)
FLOW RATE	=	2.97	(LB/SEC)
REFERRED RPM	=	14403.46	
REFERRED HORSE POWER	=	32.51	(HP)
REFERRED MOMENT	=	11.86	(FT-LB)
REFERRED FLOW RATE	=	1.93	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7239	
TOTAL/TOTAL EFFICIENCY	=	.8532	
TOTAL/STATIC PRESSURE RATIO	=	1.5878	
TOTAL/TOTAL PRESSURE RATIO	=	1.5165	
HEAD COEFFICIENT	=	4.8616	
BLADE/JET SPEED RATIO	=	.4535	
THEORETICAL DEGREE OF REACTION	=	.3052	
MACH NUMBER AT STATION 0	=	[illegible]	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	1.600	23.520	562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA# CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0995	.9033	.0967	.0967	0.0000
2	3.003	.940	0.0000	.2347	1.0461	.9019	.0981	.0981	.2585
3	3.195	1.000	.0290	.2526	1.0000	.9009	.0991	.0991	.4795
4	3.432	1.074	0.0000	.2745	.9409	.8998	.1002	.1002	.7614
5	3.627	1.135	0.0000	.2926	.8917	.8989	.1011	.1011	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	326.89	-13.11	722.13	792.78	326.89	-13.11	239.72	405.58	482.41
2	311.81	2.95	679.40	747.21	311.01	2.95	155.26	347.62	524.14
3	302.56	6.88	643.70	709.08	302.56	6.80	85.98	314.61	557.72
4	279.73	24.29	600.78	663.15	279.73	24.29	1.84	280.79	598.94
5	265.11	31.45	565.62	625.46	265.11	31.45	-67.41	275.35	633.03

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.72	.37	65.65	36.26	562.23	509.93	22.628	16.078	1.0394	1.4628
2	.67	.31	65.41	26.53	562.23	515.77	22.724	16.803	1.0350	1.3998
3	.63	.28	65.21	15.86	562.23	520.39	22.800	17.394	1.0316	1.3522
4	.59	.25	65.04	.38	562.23	525.64	22.888	18.084	1.0276	1.3006
5	.55	.24	64.89	-14.27	562.23	529.68	22.956	18.631	1.0246	1.2624

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	1.600	23.520	562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9981	.8889	.1111	.1111	0.0000
2	3.020	.925	-.0168	.2218	.8994	.8926	.1074	.1074	.2215
3	3.265	1.000	-.0405	.2447	1.0000	.8954	.1046	.1046	.4105
4	3.585	1.098	-.1537	.2747	1.1697	.8843	.1157	.1157	.7083
5	3.837	1.175	-.2100	.2983	1.3310	.8756	.1245	.1245	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	234.59	-9.41	-94.53	253.10	234.59	-9.41	-564.55	611.42	470.02
2	211.40	2.01	41.47	215.44	211.40	2.01	-485.61	529.63	527.07
3	235.03	5.38	47.96	239.94	235.03	5.38	-521.89	572.40	569.85
4	274.92	23.88	58.90	280.61	274.92	23.88	-574.87	637.68	625.77
5	312.84	37.12	44.70	318.19	312.84	37.12	-624.98	699.89	669.68

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.23	.56	-21.95	-67.44	496.86	491.53	14.279	13.750	1.6472	1.7106
2	.20	.48	11.10	-66.48	506.60	502.74	15.474	15.065	1.5200	1.5612
3	.22	.52	11.53	-65.76	507.03	502.50	15.531	15.051	1.5144	1.5627
4	.26	.58	10.49	-64.45	507.65	501.09	15.519	14.830	1.5155	1.5860
5	.29	.64	8.13	-63.41	507.62	499.20	15.411	14.535	1.5262	1.6182

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	522.64	17.525	1.3
2	526.08	18.008	1.2
3	529.77	18.515	1.2
4	534.93	19.229	1.3
5	539.96	19.928	1.4

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	1.600	23.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.7186	1.6472	.8177	.8750	4.1282	.4922	.2757
2	1.5612	1.5200	.8279	.8776	2.9392	.5833	.2334
3	1.5627	1.5144	.8199	.8780	2.6011	.6200	.3102
4	1.5868	1.5155	.7864	.8668	2.3254	.6558	.4141
5	1.6182	1.5262	.7560	.8537	2.1662	.6794	.4987

MASS AVERAGED QUANTITIES

HORSE POWER = 56.33 (HP)
MOMENT = 14.79 (FT-LB)
FLOW RATE = 2.95 (LB/SEC)

REFERRED RPM = 19204.61
REFERRED HORSE POWER = 33.81 (HP)
REFERRED MOMENT = 9.25 (FT-LB)
REFERRED FLOW RATE = 1.92 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .8052
TOTAL/TOTAL EFFICIENCY= .8717
TOTAL/STATIC PRESSURE RATIO = 1.5936
TOTAL/TOTAL PRESSURE RATIO = 1.5342

HEAD COEFFICIENT = 2.7532
BLADE/JET SPEED RATIO = .6027
THEORETICAL DEGREE OF REACTION= .3362
MACH NUMBER AT STATION 0 = .1912

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	25000.0	1.600	23.520	562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1009	.9084	.0916	.0916	0.0000
2	3.003	.940	0.0000	.2347	1.0467	.9063	.0937	.0937	.2584
3	3.195	1.000	.0290	.2526	1.0000	.9047	.0953	.0953	.4794
4	3.432	1.074	0.0000	.2745	.9403	.9031	.0969	.0969	.7613
5	3.627	1.135	0.0000	.2926	.8908	.9018	.0982	.0982	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	332.96	-13.36	735.53	807.49	332.96	-13.36	132.52	358.61	603.01
2	316.55	3.01	691.51	760.53	316.55	3.01	36.34	318.65	655.17
3	302.44	6.92	654.81	721.32	302.44	6.92	-42.34	305.47	697.15
4	284.39	24.70	610.80	674.22	284.39	24.70	-137.87	317.01	748.67
5	269.41	31.96	574.81	635.61	269.41	31.96	-216.49	347.09	791.29

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.73	.32	65.65	21.70	562.23	507.97	22.646	15.875	1.0386	1.4815
2	.68	.29	65.41	6.55	562.23	514.10	22.733	16.620	1.0346	1.4152
3	.65	.27	65.21	-7.97	562.23	518.93	22.804	17.227	1.0314	1.3653
4	.60	.28	65.04	-25.87	562.23	524.40	22.889	17.937	1.0276	1.3112
5	.56	.31	64.89	-38.79	562.23	528.61	22.955	18.499	1.0246	1.2714

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	25000.0	1.600	23.520	562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0078	.9043	.0968	.0968	0.0000
2	3.020	.925	-.0168	.2218	.8666	.8845	.1156	.1156	.2132
3	3.265	1.000	-.0405	.2447	1.0000	.8704	.1297	.1297	.3955
4	3.585	1.098	-.1537	.2747	1.2198	.8796	.1204	.1204	.6949
5	3.837	1.175	-.2100	.2983	1.4240	.8869	.1132	.1132	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	233.41	-9.36	25.81	235.02	233.41	-9.36	-561.71	608.35	587.57
2	200.70	1.91	197.80	281.80	200.70	1.91	-461.04	502.83	658.84
3	231.59	5.30	198.07	304.78	231.59	5.30	-514.25	564.02	712.31
4	282.50	24.54	191.49	342.17	282.50	24.54	-590.72	655.25	782.21
5	329.78	39.13	178.27	376.92	329.78	39.13	-656.83	737.80	837.11

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.22	.56	6.31	-67.44	490.94	486.34	13.757	13.312	1.7076	1.7669
2	.26	.46	44.59	-66.48	508.52	501.91	15.692	14.990	1.4988	1.5690
3	.28	.51	40.54	-65.76	509.74	502.01	15.741	14.921	1.4942	1.5763
4	.31	.60	34.13	-64.45	511.05	501.31	15.846	14.805	1.4852	1.5897
5	.34	.67	26.40	-63.41	511.37	499.55	15.815	14.572	1.4872	1.6141

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	512.14	16.901	1.3
2	522.95	17.643	1.2
3	528.48	18.361	1.2
4	537.04	19.496	1.3
5	544.84	20.565	1.4

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	1.600	23.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.7669	1.7096	.8448	.8926	2.7088	.5988	.2922
2	1.5690	1.4968	.7911	.8750	1.9008	.7253	.3179
3	1.5763	1.4942	.7658	.8614	1.6948	.7681	.3018
4	1.5887	1.4852	.7348	.8518	1.4933	.8183	.3986
5	1.6141	1.4872	.7076	.8438	1.3796	.8514	.4814

MASS AVERAGED QUANTITIES

HORSE POWER	=	53.63	(HP)
MOMENT	=	11.27	(FT-LB)
FLOW RATE	=	2.92	(LB/SEC)
REFERRED RPM	=	24005.76	
REFERRED HORSE POWER	=	32.19	(HP)
REFERRED MOMENT	=	7.04	(FT-LB)
REFERRED FLOW RATE	=	1.90	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7670	
TOTAL/TOTAL EFFICIENCY	=	.8641	
TOTAL/STATIC PRESSURE RATIO	=	1.6061	
TOTAL/TOTAL PRESSURE RATIO	=	1.5192	
HEAD COEFFICIENT	=	1.7933	
BLADE/JET SPEED RATIO	=	.7468	
THEORETICAL DEGREE OF REACTION	=	.3263	
MACH NUMBER AT STATION 0	=	.1809	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	30000.0	1.600	23.520	562.23

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1019	.9121	.0879	.0879	0.0000
2	3.003	.940	0.0000	.2347	1.0471	.9094	.0906	.0906	.2580
3	3.195	1.000	.0290	.2526	1.0000	.9072	.0928	.0928	.4789
4	3.432	1.074	0.0000	.2745	.9400	.9053	.0947	.0947	.7609
5	3.627	1.135	0.0000	.2926	.8902	.9038	.0962	.0962	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	341.40	-13.69	754.17	827.96	341.40	-13.69	30.56	343.04	723.62
2	324.41	3.08	708.67	779.40	324.41	3.08	-77.53	333.56	786.21
3	305.59	7.09	670.80	738.93	305.59	7.09	-165.78	347.73	836.58
4	291.23	25.29	625.48	690.42	291.23	25.29	-272.93	399.93	898.41
5	275.81	32.72	588.46	650.71	275.81	32.72	-361.09	455.55	949.55

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.75	.31	65.65	5.12	562.23	505.19	22.636	15.566	1.0391	1.5110
2	.70	.30	65.41	-13.44	562.23	511.68	22.719	16.338	1.0352	1.4395
3	.66	.31	65.21	-28.48	562.23	516.80	22.788	16.968	1.0321	1.3862
4	.62	.36	65.04	-43.15	562.23	522.56	22.873	17.706	1.0283	1.3284
5	.58	.40	64.89	-52.63	562.23	527.00	22.939	18.290	1.0253	1.2860

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	30000.0	1.600	23.520	562.23

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZLTA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0177	.8859	.1142	.1142	0.0000
2	3.020	.925	-.0168	.2218	.8324	.8803	.1197	.1197	.2019
3	3.265	1.000	-.0405	.2447	1.0000	.8761	.1239	.1239	.3775
4	3.585	1.098	-.1537	.2747	1.2735	.8864	.1136	.1136	.6802
5	3.837	1.175	-.2100	.2983	1.5233	.8946	.1055	.1055	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	230.49	-9.25	150.36	275.35	230.49	-9.25	-554.67	600.72	705.03
2	188.52	1.79	357.56	404.22	188.52	1.79	-433.05	472.31	790.61
3	226.47	5.18	351.91	418.51	226.47	5.18	-502.87	551.54	854.78
4	288.41	25.05	335.58	443.19	288.41	25.05	-603.08	668.96	938.65
5	344.98	40.93	315.33	469.17	344.98	40.93	-689.19	771.80	1004.53

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.26	.56	33.12	-67.44	489.05	482.74	13.508	12.908	1.7411	1.8221
2	.37	.43	62.20	-66.48	516.55	502.95	16.594	15.115	1.4174	1.5561
3	.38	.50	57.24	-65.76	518.90	504.11	16.786	15.170	1.4011	1.5504
4	.40	.61	49.33	-64.45	521.13	504.79	16.963	15.173	1.3865	1.5501
5	.43	.70	42.43	-63.41	521.95	503.64	16.976	14.981	1.3854	1.5700

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	512.77	16.399	1.3
2	521.52	17.464	1.2
3	529.42	18.463	1.2
4	542.03	20.123	1.3
5	553.20	21.676	1.4

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	1.600	23.520	562.23

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.8221	1.7411	.8263	.8884	2.0327	.7014	.2938
2	1.5561	1.4174	.6846	.8565	1.2972	.8780	.1669
3	1.5584	1.4011	.6545	.8390	1.1368	.9379	.2435
4	1.5501	1.3865	.6210	.8200	.9854	1.0074	.3380
5	1.5700	1.3854	.5925	.8055	.9060	1.0506	.4265

MASS AVERAGED QUANTITIES

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             HORSE POWER =      45.44   (HP)
             MOMENT      =       7.96   (FT-LB)
             FLOW RATE   =       2.93   (LB/SEC)

      REFERRED  RPM      =   28806.91
      REFERRED HORSE POWER =    27.27   (HP)
      REFERRED MOMENT    =       4.97   (FT-LB)
      REFERRED FLOW RATE =       1.91   (LB/SEC)

    TOTAL/STATIC EFFICIENCY =    .6674
    TOTAL/TOTAL  EFFICIENCY=     .8406
 TOTAL/STATIC PRESSURE RATIO =  1.5082
 TOTAL/TOTAL  PRESSURE RATIO =  1.4421

HEAD COEFFICIENT             =  1.2222
BLADE/JET SPEED RATIO        =   .9045
THEORETICAL DEGREE OF REACTION=  .2771
MACH NUMBER AT STATION 0     =   .1898
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SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	5000.0	1.800	26.460	557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1053	.9157	.0843	.0843	0.0000
2	3.003	.940	0.0000	.2347	1.0484	.9088	.0912	.0912	.2504
3	3.195	1.000	.0290	.2526	1.0000	.9033	.0967	.0967	.4689
4	3.432	1.074	0.0000	.2745	.9390	.8983	.1017	.1017	.7530
5	3.627	1.135	0.0000	.2926	.8888	.8941	.1059	.1059	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	439.17	-17.62	970.14	1065.06	439.17	-17.62	849.54	956.50	120.60
2	416.55	3.96	909.97	1000.79	416.55	3.96	778.93	883.33	131.03
3	402.67	9.09	860.27	947.64	402.67	9.09	720.84	825.73	139.43
4	373.11	32.41	801.34	884.53	373.11	32.41	651.60	751.56	149.73
5	353.15	41.90	753.46	833.17	353.15	41.90	595.20	693.35	158.26

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	1.01	.91	65.65	62.67	557.30	462.91	24.762	12.933	1.0686	2.0459
2	.94	.83	65.41	61.87	557.30	473.96	24.862	14.103	1.0643	1.8762
3	.88	.77	65.21	60.82	557.30	482.57	24.957	15.078	1.0602	1.7540
4	.81	.69	65.04	60.21	557.30	492.20	25.098	16.249	1.0543	1.6285
5	.76	.63	64.89	59.32	557.30	499.54	25.213	17.191	1.0495	1.5392

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	5000.0	1.800	26.460	557.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9717	.7723	.2278	.2278	0.0000
2	3.020	.925	-.0168	.2218	1.0028	.7702	.2298	.2298	.2402
3	3.265	1.000	-.0405	.2447	1.0000	.7687	.2313	.2313	.4435
4	3.585	1.098	-.1537	.2747	1.0235	.7666	.2335	.2335	.7363
5	3.837	1.175	-.2100	.2983	1.0613	.7649	.2352	.2352	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	298.76	-11.98	-601.46	671.68	298.76	-11.98	-718.97	778.66	117.50
2	308.34	2.93	-576.53	653.81	308.34	2.93	-708.29	772.50	131.77
3	307.47	7.04	-540.27	621.68	307.47	7.04	-682.74	748.81	142.46
4	314.69	27.33	-501.59	592.77	314.69	27.33	-658.03	729.92	156.44
5	326.33	38.72	-484.51	585.44	326.33	38.72	-651.94	730.08	167.42

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.62	.72	-63.59	-67.44	526.07	488.52	18.159	14.014	1.4571	1.8882
2	.60	.71	-61.87	-66.48	524.81	489.24	18.093	14.152	1.4625	1.8697
3	.57	.69	-60.36	-65.76	524.53	492.72	18.244	14.657	1.4503	1.8053
4	.54	.67	-57.90	-64.45	524.27	495.03	18.397	15.049	1.4383	1.7582
5	.54	.67	-56.04	-63.41	523.96	495.44	18.425	15.147	1.4361	1.7468

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	538.98	22.027	1.6
2	538.90	22.106	1.6
3	539.38	22.259	1.5
4	539.37	22.384	1.5
5	539.79	22.547	1.5

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	5000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.8863	1.4571	.3375	.5494	76.4640	.1144	-.1139
2	1.9672	1.4625	.3561	.5664	63.0575	.1251	-.0051
3	1.8533	1.4563	.3787	.5835	53.4993	.1367	.0442
4	1.7582	1.4383	.3980	.6009	44.4277	.1499	.1266
5	1.7460	1.4361	.4062	.6091	39.3928	.1593	.2131

MASS AVERAGED QUANTITIES

HORSE POWER =	40.88	(HP)
MOMENT =	42.85	(FT-LB)
FLOW RATE =	3.68	(LB/SEC)
REFERRED RPM =	4022.34	
REFERRED HORSE POWER =	21.86	(HP)
REFERRED MOMENT =	23.81	(FT-LB)
REFERRED FLOW RATE =	2.12	(LB/SEC)
TOTAL/STATIC EFFICIENCY =	.3761	
TOTAL/TOTAL EFFICIENCY=	.5825	
TOTAL/STATIC PRESSURE RATIO =	1.8127	
TOTAL/TOTAL PRESSURE RATIO =	1.4494	
HEAD COEFFICIENT =	54.9407	
BLADE/JET SPEED RATIO =	.1349	
THEORETICAL DEGREE OF REACTION=	.0538	
MACH NUMBER AT STATION 0 =	.2117	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	10000.0	1.800	26.460	557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1035	.9052	.0948	.0948	0.0000
2	3.003	.940	0.0000	.2347	1.0475	.8991	.1009	.1009	.2544
3	3.195	1.000	.0290	.2526	1.0000	.8942	.1058	.1058	.4742
4	3.432	1.074	0.0000	.2745	.9482	.8911	.1089	.1089	.7575
5	3.627	1.135	0.0000	.2926	.8910	.8885	.1115	.1115	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	387.07	-15.53	855.05	938.71	387.07	-15.53	613.85	725.86	241.[illegible]
2	367.44	3.49	802.69	882.80	367.44	3.49	540.62	653.68	[illegible].07
3	350.78	8.03	759.46	836.60	350.78	8.03	480.60	595.05	[illegible].86
4	329.81	28.64	708.35	781.89	329.81	28.64	408.88	526.10	[illegible].47
5	312.54	37.08	666.82	737.36	312.54	37.08	350.30	470.92	316.[illegible]

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/STAT	TOT/STA
1	.87	.67	65.65	57.77	557.30	483.98	25.020	15.[illegible]	1.[illegible]	1.[illegible]
2	.81	.60	65.41	55.80	557.30	492.45	25.117	16.[illegible]	1.[illegible]	1.[illegible]
3	.76	.54	65.21	53.88	557.30	499.06	25.204	17.[illegible]	1.[illegible]	1.[illegible]
4	.71	.48	65.04	51.11	557.30	506.43	25.340	18.[illegible]	1.[illegible]	1.[illegible]
5	.66	.42	64.89	48.26	557.30	512.06	25.447	[illegible]	1.[illegible]	1.[illegible]

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	18000.0	1.800	26.460	557.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0718	.1912	.9784	.8232	.1768	.1768	0.0000
2	3.020	.925	-.0168	.2218	.9754	.8245	.1755	.1755	.2363
3	3.265	1.000	-.0405	.2447	1.0000	.8255	.1745	.1745	.4364
4	3.585	1.098	-.1537	.2747	1.0638	.8335	.1666	.1666	.7296
5	3.837	1.175	-.2100	.2983	1.1358	.8397	.1603	.1603	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	279.90	-11.23	-438.57	520.40	279.90	-11.23	-673.58	729.51	235.01
2	279.04	2.65	-377.45	469.40	279.04	2.65	-640.98	699.09	263.54
3	286.08	6.55	-350.30	452.32	286.08	6.55	-635.23	696.71	284.93
4	304.34	26.43	-323.50	444.94	304.34	26.43	-636.39	705.91	312.88
5	324.93	38.55	-314.30	453.71	324.93	38.55	-649.14	726.95	334.84

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.48	.68	-57.46	-67.44	505.82	483.29	16.625	14.174	1.5916	1.8668
2	.43	.65	-53.53	-66.48	505.74	487.40	16.794	14.758	1.5756	1.7929
3	.42	.64	-50.77	-65.76	505.44	488.42	16.834	14.932	1.5718	1.7721
4	.41	.65	-46.75	-64.45	505.15	488.68	16.923	15.069	1.5636	1.7559
5	.42	.67	-44.05	-63.41	504.66	487.53	16.921	14.994	1.5638	1.7647

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	527.57	20.652	1.5
2	528.07	20.801	1.4
3	528.81	20.975	1.4
4	530.14	21.275	1.4
5	531.50	21.558	1.4

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.8668	1.5916	.5655	.7429	18.8039	.2306	.1102
2	1.7929	1.5756	.6022	.7596	14.9821	.2584	.1576
3	1.7721	1.5718	.6170	.7677	12.9877	.2775	.2250
4	1.7559	1.5636	.6298	.7806	11.0959	.3002	.3105
5	1.7647	1.5638	.6306	.7877	10.0133	.3160	.3900

MASS AVERAGED QUANTITIES

HORSE POWER	=	62.51	(HP)
MOMENT	=	32.83	(FT-LB)
FLOW RATE	=	3.54	(LB/SEC)
REFERRED RPM	=	9644.68	
REFERRED HORSE POWER	=	33.50	(HP)
REFERRED MOMENT	=	18.24	(FT-LB)
REFERRED FLOW RATE	=	2.04	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.6118	
TOTAL/TOTAL EFFICIENCY	=	.7683	
TOTAL/STATIC PRESSURE RATIO	=	1.7842	
TOTAL/TOTAL PRESSURE RATIO	=	1.5722	
HEAD COEFFICIENT	=	13.3686	
BLADE/JET SPEED RATIO	=	.2735	
THEORETICAL DEGREE OF REACTION	=	.2358	
MACH NUMBER AT STATION 0	=	.2036	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	15000.0	1.800	26.460	557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0986	.9007	.0993	.0993	0.0000
2	3.003	.940	0.0000	.2347	1.0456	.8995	.1005	.1005	.2550
3	3.195	1.000	.0290	.2526	1.0000	.8986	.1014	.1014	.4750
4	3.432	1.074	0.0000	.2745	.9415	.8984	.1016	.1016	.7582
5	3.627	1.135	0.0000	.2926	.8929	.8982	.1018	.1018	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	367.32	-14.73	811.42	890.81	367.32	-14.73	449.61	580.76	361.81
2	349.62	3.32	763.74	839.96	349.62	3.32	370.64	509.52	393.10
3	338.52	7.65	723.92	797.44	338.52	7.65	305.62	456.13	418.29
4	314.81	27.34	676.12	746.32	314.81	27.34	226.92	389.03	449.20
5	298.55	35.42	636.97	704.35	298.55	35.42	162.19	341.60	474.77

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.82	.53	65.65	50.76	557.30	491.27	25.113	16.151	1.0536	1.6383
2	.77	.47	65.41	46.68	557.30	498.59	25.262	17.111	1.0474	1.5464
3	.72	.41	65.21	42.08	557.30	504.39	25.380	17.900	1.0426	1.4782
4	.67	.35	65.04	35.79	557.30	510.95	25.522	18.834	1.0367	1.4049
5	.63	.31	64.89	28.52	557.30	516.02	25.630	19.578	1.0324	1.3515

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	15000.0	1.800	26.460	557.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X-R/RM	RADIAL SHIFT	BLADE OPENING	Y-VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	[illegible]	.0718	.1912	.9852	.8597	.1404	.1404	0.0000
2	3.020	[illegible]	-.0168	[illegible]	.9474	.8666	.1334	.1334	.2301
3	3.265	1.000	-.0405	.2447	1.0000	.8719	.1282	.1202	.4266
4	3.585	1.098	-.1532	.2747	1.1020	.8786	.1214	.1214	.7217
5	3.837	1.175	-.2190	.2983	1.2063	.8839	.1162	.1162	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	275.35	-11.05	-310.15	414.89	275.36	-11.05	-662.66	717.68	352.51
2	264.80	2.52	-212.98	339.84	264.80	2.52	-608.29	663.43	395.31
3	279.51	6.40	-193.25	339.87	279.51	6.40	-620.64	680.71	427.39
4	308.03	26.75	-174.77	355.17	308.03	26.75	-644.10	714.47	469.33
5	337.17	40.00	-171.32	380.31	337.17	40.00	-673.59	754.32	502.26

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.39	.67	-48.40	-67.44	490.25	475.92	15.224	13.723	1.7381	1.9281
2	.32	.62	-38.81	-66.48	493.32	483.71	15.823	14.771	1.6722	1.7914
3	[illegible]	.63	-34.66	-65.76	493.16	483.78	15.875	14.843	1.6668	1.7826
4	.33	.66	-29.57	-64.45	493.10	482.61	15.932	14.777	1.6608	1.7907
5	.35	.70	-26.94	-63.41	492.65	480.62	15.904	14.586	1.6637	1.8141

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	518.78	19.545	1.4
2	520.34	19.868	1.3
3	522.34	20.230	1.4
4	525.08	20.721	1.4
5	527.96	21.211	1.5

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.9281	1.7381	.7035	.8236	8.7505	.3381	.2309
2	1.7914	1.6722	.7482	.8403	6.6497	.3878	.2367
3	1.7826	1.6668	.7560	.8475	5.8274	.4142	.3059
4	1.7987	1.6608	.7513	.8538	5.0891	.4433	.3963
5	1.8141	1.6637	.7414	.8571	4.6491	.4638	.4730

MASS AVERAGED QUANTITIES

HORSE POWER	=	76.87	(HP)
MOMENT	=	26.91	(FT-LB)
FLOW RATE	=	3.51	(LB/SEC)
REFERRED RPM	=	14467.03	
REFERRED HORSE POWER	=	41.19	(HP)
REFERRED MOMENT	=	14.95	(FT-LB)
REFERRED FLOW RATE	=	2.02	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7445	
TOTAL/TOTAL EFFICIENCY	=	.8455	
TOTAL/STATIC PRESSURE RATIO	=	1.8090	
TOTAL/TOTAL PRESSURE RATIO	=	1.6751	
HEAD COEFFICIENT	=	6.0665	
BLADE/JET SPEED RATIO	=	.4060	
THEORETICAL DEGREE OF REACTION	=	.3227	
MACH NUMBER AT STATION 8	=	.2014	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	1.800	26.460	557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.0996	.9048	.0952	.0952	0.0000
2	3.003	.940	0.0000	.2347	1.0461	.9034	.0966	.0966	.2565
3	3.195	1.000	.0290	.2526	1.0000	.9023	.0977	.0977	.4770
4	3.432	1.074	0.0000	.2745	.9468	.9012	.0988	.0988	.7596
5	3.627	1.135	0.0000	.2926	.8916	.9002	.0998	.0998	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	352.31	-14.13	778.26	854.40	352.31	-14.13	295.85	460.27	482.41
2	335.18	3.18	732.20	805.27	335.18	3.18	208.06	394.51	524.14
3	329.48	7.33	693.70	764.16	329.48	7.33	135.98	356.51	557.22
4	301.44	26.18	647.42	714.64	301.44	26.18	48.48	306.44	598.94
5	285.67	33.89	609.50	673.98	285.67	33.89	-23.53	268.64	633.03

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.78	.42	65.65	40.02	557.30	496.56	25.287	16.384	1.0464	1.5672
2	.73	.36	65.41	31.83	557.30	503.34	25.414	17.794	1.0412	1.4870
3	.69	.32	65.21	22.43	557.30	508.71	25.515	18.541	1.0370	1.4271
4	.64	.28	65.04	9.14	557.30	514.80	25.631	19.418	1.0323	1.3627
5	.60	.26	64.89	-4.71	557.30	519.50	25.721	20.115	1.0287	1.3154

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	1.800	26.460	557.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZLIA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9937	.8069	.1131	.1131	0.0000
2	3.020	.925	-.0148	.2218	.9145	.8915	.1085	.1085	.2243
3	3.265	1.000	-.0405	.2447	1.0000	.8950	.1050	.1050	.4169
4	3.585	1.098	-.1537	.2747	1.1464	.8861	.1140	.1146	.7142
5	3.837	1.175	-.2100	.2983	1.2882	.8790	.1210	.1210	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	268.07	-10.75	-175.09	320.36	268.07	-10.75	-645.11	698.67	470.02
2	246.71	2.34	-39.64	249.88	246.71	2.34	-566.72	618.09	527.07
3	269.76	6.17	-29.15	271.40	269.76	6.17	-599.00	656.97	569.85
4	309.25	26.86	-20.91	311.13	309.26	26.86	-646.68	717.33	625.72
5	347.51	41.23	-24.56	350.81	347.51	41.23	-694.24	777.45	669.68

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.30	.66	-33.15	-67.44	481.12	472.56	14.545	13.661	1.8191	1.9378
2	.23	.57	-9.13	-65.48	489.95	484.76	15.744	15.168	1.6806	1.7445
3	.25	.61	-6.17	-65.76	490.15	484.51	15.789	15.162	1.6759	1.7451
4	.29	.67	-3.87	-64.45	490.59	482.53	15.759	14.871	1.6791	1.7792
5	.33	.72	-4.04	-63.41	490.35	480.11	15.619	14.507	1.6940	1.8239

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	513.20	18.949	1.4
2	516.55	19.483	1.3
3	520.42	20.079	1.3
4	525.35	20.846	1.4
5	530.41	21.632	1.5

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	1.9358	1.8191	.7943	.8699	4.9528	.4493	.3000
2	1.7445	1.6906	.8221	.8766	3.5835	.5283	.2709
3	1.7351	1.6759	.8193	.8785	3.1668	.5619	.3430
4	1.7792	1.6791	.7887	.8698	2.8337	.5940	.4425
5	1.8239	1.6940	.7614	.8593	2.6368	.6158	.5225

MASS AVERAGED QUANTITIES

HORSE POWER	=	81.09	(HP)
MOMENT	=	21.30	(FT-LB)
FLOW RATE	=	3.51	(LB/SEC)
REFERRED RPM	=	19289.37	
REFERRED HORSE POWER	=	43.45	(HP)
REFERRED MOMENT	=	11.83	(FT-LB)
REFERRED FLOW RATE	=	2.02	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.8020	
TOTAL/TOTAL EFFICIENCY	=	.8721	
TOTAL/STATIC PRESSURE RATIO	=	1.7873	
TOTAL/TOTAL PRESSURE RATIO	=	1.6980	
HEAD COEFFICIENT	=	3.3447	
BLADE/JET SPEED RATIO	=	.5468	
THEORETICAL DEGREE OF REACTION	=	.3669	
MACH NUMBER AT STATION 0	=	.2015	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	25000.0	1.800	26.460	557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1008	.9085	.0915	.0915	0.0000
2	3.003	.940	0.0000	.2347	1.0466	.9064	.0936	.0936	.2567
3	3.195	1.000	.0290	.2526	1.0000	.9047	.0953	.0953	.4772
4	3.432	1.074	0.0000	.2745	.9404	.9032	.0968	.0968	.7598
5	3.627	1.135	0.0000	.2926	.8909	.9019	.0981	.0981	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	353.56	-14.18	781.02	857.44	353.56	-14.18	178.01	396.09	603.01
2	336.16	3.19	734.34	807.63	336.16	3.19	79.17	345.37	655.17
3	330.62	7.35	695.41	766.04	330.62	7.35	-1.74	330.71	697.15
4	302.05	26.23	648.72	716.07	302.05	26.23	-99.95	319.24	748.67
5	286.15	33.95	610.53	675.11	286.15	33.95	-180.77	340.17	791.29

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.79	.36	65.65	26.73	557.30	496.12	25.328	16.860	1.0447	1.5694
2	.73	.31	65.41	13.25	557.30	503.02	25.443	17.275	1.0400	1.4886
3	.69	.30	65.21	-.30	557.30	508.47	25.535	18.525	1.0362	1.4283
4	.64	.29	65.04	-18.31	557.30	514.63	25.646	19.406	1.0317	1.3635
5	.60	.30	64.89	-32.28	557.30	519.37	25.732	20.106	1.0283	1.3160

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	25000.0	1.800	26.460	557.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0024	.9035	.0966	.0966	0.0000
2	3.020	.925	-.0168	.2218	.8851	.8858	.1143	.1143	.2176
3	3.265	1.000	-.0405	.2447	1.0000	.8725	.1275	.1275	.4048
4	3.585	1.098	-.1537	.2747	1.1867	.8819	.1181	.1181	.7035
5	3.837	1.175	-.2100	.2983	1.3613	.8893	.1108	.1108	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	269.51	-10.81	-61.06	276.55	269.51	-10.81	-648.58	702.43	587.52
2	237.98	2.26	112.18	263.10	237.98	2.26	-546.66	596.22	658.84
3	268.87	6.15	115.30	292.61	268.87	6.15	-597.01	654.79	712.31
4	319.86	27.71	115.04	340.30	319.06	27.71	-667.17	740.06	782.21
5	366.00	43.42	105.92	383.48	366.00	43.42	-731.19	818.83	837.11

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.26	.66	-12.77	-67.44	472.95	466.59	13.797	13.158	1.9128	2.0110
2	.24	.55	25.24	-66.48	489.53	483.77	15.720	15.032	1.6832	1.7544
3	.27	.61	23.21	-65.76	490.29	483.67	15.701	14.972	1.6853	1.7673
4	.32	.69	19.83	-64.45	491.45	481.81	15.794	14.736	1.6753	1.7956
5	.36	.76	16.14	-63.41	491.66	479.42	15.768	14.436	1.6781	1.8329

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	507.64	18.270	1.4
2	513.35	19.085	1.3
3	519.35	19.950	1.3
4	527.38	21.142	1.4
5	535.21	22.335	1.5

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.0110	1.9170	.8365	.8915	3.3326	.5478	.3322
2	1.7544	1.6832	.8196	.8797	2.3150	.6572	.2758
3	1.7673	1.6853	.8009	.8681	2.0690	.6952	.3550
4	1.7956	1.6753	.7673	.8621	1.8400	.7372	.4495
5	1.8329	1.6781	.7411	.8568	1.7001	.7669	.5253

MASS AVERAGED QUANTITIES

HORSE POWER	=	81.93	(HP)
MOMENT	=	17.21	(FT-LB)
FLOW RATE	=	3.52	(LB/SEC)
REFERRED RPM	=	24111.71	
REFERRED HORSE POWER	=	43.90	(HP)
REFERRED MOMENT	=	9.56	(FT-LB)
REFERRED FLOW RATE	=	2.03	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7941	
TOTAL/TOTAL EFFICIENCY	=	.8710	
TOTAL/STATIC PRESSURE RATIO	=	1.8098	
TOTAL/TOTAL PRESSURE RATIO	=	1.7105	
HEAD COEFFICIENT	=	2.1851	
BLADE/JET SPEED RATIO	=	.6765	
THEORETICAL DEGREE OF REACTION	=	.3773	
MACH NUMBER AT STATION 0	=	.2022	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	30000.0	1.800	26.460	557.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1018	.9124	.0876	.0076	0.0000
2	3.003	.940	0.0000	.2347	1.0470	.9096	.0904	.0904	.2562
3	3.195	1.000	.0290	.2526	1.0000	.9073	.0927	.0927	.4766
4	3.432	1.074	0.0000	.2745	.9400	.9055	.0945	.0945	.7593
5	3.627	1.135	0.0000	.2926	.8903	.9039	.0961	.0961	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	362.67	-14.55	801.15	879.53	362.67	-14.55	77.53	371.15	723.62
2	344.62	3.27	752.84	827.97	344.62	3.27	-33.37	346.25	786.21
3	335.37	7.53	712.63	785.01	335.37	7.53	-123.95	357.63	836.58
4	309.41	26.87	664.52	733.51	309.41	26.87	-233.89	388.79	898.41
5	293.04	34.77	625.22	691.36	293.04	34.77	-324.33	438.49	949.55

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.81	.34	65.65	12.07	557.30	492.93	25.317	16.476	1.0452	1.6060
2	.76	.32	65.41	-5.53	557.30	500.26	25.425	17.423	1.0407	1.5187
3	.71	.32	65.21	-20.29	557.30	506.02	25.514	18.200	1.0371	1.4539
4	.66	.35	65.04	-37.09	557.30	512.53	25.625	19.115	1.0326	1.3843
5	.62	.39	64.89	-47.90	557.30	517.53	25.711	19.841	1.0291	1.3336

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
	2	30000.0	1.800	26.460	557.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA# CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0116	.9130	.0870	.0870	0.0000
2	3.020	.925	-.0168	.2218	.8541	.8930	.1070	.1070	.2084
3	3.265	1.000	-.0405	.2447	1.0000	.8780	.1221	.1221	.3899
4	3.585	1.098	-.1537	.2747	1.2331	.8875	.1125	.1125	.6913
5	3.837	1.175	-.2100	.2983	1.4460	.8950	.1051	.1051	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	265.45	-10.65	66.22	273.79	265.45	-10.65	-638.81	691.85	705.03
2	224.13	2.13	275.76	355.36	224.13	2.13	-514.85	561.52	790.61
3	262.40	6.00	272.12	378.07	262.40	6.00	-582.66	639.05	854.78
4	323.58	28.10	262.04	417.32	323.58	28.10	-676.61	750.53	938.65
5	379.44	45.02	246.49	454.71	379.44	45.02	-758.03	848.89	1004.53

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.26	.66	14.01	-67.44	468.59	462.35	13.407	12.793	1.9736	2.0683
2	.33	.52	50.90	-66.48	495.08	484.57	16.422	15.234	1.6113	1.7369
3	.35	.59	46.05	-65.76	496.79	485.24	16.490	15.186	1.6047	1.7424
4	.39	.70	39.00	-64.45	498.88	484.39	16.656	15.023	1.5886	1.7613
5	.42	.79	33.01	-63.41	499.71	482.50	16.671	14.747	1.5872	1.7942

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	502.18	17.584	1.4
2	510.81	18.744	1.2
3	519.23	19.917	1.3
4	531.26	21.673	1.4
5	542.46	23.394	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	1.800	26.460	557.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.8683	1.9736	.8490	.9017	2.3981	.6457	.3248
2	1.7369	1.6113	.7651	.8763	1.5811	.7953	.2288
3	1.7424	1.6047	.7401	.8591	1.4037	.8440	.3087
4	1.7613	1.5886	.7020	.8463	1.2390	.8984	.4058
5	1.7942	1.5872	.6719	.8359	1.1425	.9356	.4867

MASS AVERAGED QUANTITIES

HORSE POWER	=	75.08	(HP)
MOMENT	=	13.14	(FT-LB)
FLOW RATE	=	3.53	(LB/SEC)
REFERRED RPM	=	28934.05	
REFERRED HORSE POWER	=	40.23	(HP)
REFERRED MOMENT	=	7.30	(FT-LB)
REFERRED FLOW RATE	=	2.03	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7419	
TOTAL/TOTAL EFFICIENCY	=	.8626	
TOTAL/STATIC PRESSURE RATIO	=	1.7930	
TOTAL/TOTAL PRESSURE RATIO	=	1.6462	
HEAD COEFFICIENT	=	1.4986	
BLADE/JET SPEED RATIO	=	.8169	
THEORETICAL DEGREE OF REACTION	=	.3373	
MACH NUMBER AT STATION 0	=	.2025	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	5000.0	2.000	29.400	591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1063	.9231	.0769	.0769	0.0000
2	3.003	.940	0.0080	.2347	1.0488	.9158	.0842	.0842	.2493
3	3.195	1.000	.0290	.2526	1.0000	.9100	.0900	.0900	.4668
4	3.432	1.074	0.0000	.2745	.9385	.9046	.0954	.0954	.7510
5	3.627	1.135	0.0000	.2926	.8879	.9001	.0999	.0999	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	488.05	-19.58	1078.13	1183.62	488.05	-19.58	957.53	1074.92	120.60
2	462.68	4.40	1010.73	1111.61	462.68	4.40	879.70	993.96	131.03
3	447.96	10.09	955.11	1052.11	447.96	10.09	815.68	930.65	139.43
4	414.01	35.96	889.19	981.51	414.01	35.96	739.46	848.23	149.73
5	391.68	46.47	835.68	924.08	391.68	46.47	677.42	783.88	158.26

STREAM LINE	MACH NUMBER ABSOLUTE	MACH NUMBER RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	FLOW ANGLE (DEG) RELATIVE	TEMPERATURE (DEG. R) TOTAL	TEMPERATURE (DEG. R) STATIC	PRESSURE (PSI) TOTAL	PRESSURE (PSI) STATIC	PRESSURE RATIO TOT/TOT	PRESSURE RATIO TOT/STA
1	1.11	1.01	65.65	63.00	591.01	474.43	27.346	12.674	1.0751	2.3197
2	1.03	.92	65.41	62.26	591.01	488.19	27.456	14.064	1.0708	2.0905
3	.96	.85	65.21	61.23	591.01	498.90	27.564	15.234	1.0666	1.9299
4	.89	.77	65.04	60.76	591.01	510.85	27.732	16.650	1.0601	1.7658
5	.83	.70	64.89	59.97	591.01	519.95	27.869	17.800	1.0549	1.6517

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	5000.0	2.000	29.400	591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9713	.7753	.2248	.2248	0.0000
2	3.028	.925	-.0168	.2218	1.0055	.7718	.2282	.2282	.2393
3	3.265	1.000	-.0405	.2447	1.0000	.7692	.2308	.2308	.4424
4	3.585	1.098	-.1537	.2747	1.0194	.7655	.2345	.2345	.7357
5	3.837	1.175	-.2100	.2983	1.0538	.7627	.2374	.2374	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	336.20	-13.49	-691.57	769.08	336.20	-13.49	-809.08	876.25	117.50
2	348.06	3.31	-667.76	753.03	348.06	3.31	-799.53	872.01	131.77
3	346.15	7.92	-626.16	715.52	346.15	7.92	-768.62	843.01	142.46
4	352.86	30.65	-581.39	680.78	352.86	30.65	-737.84	818.44	156.44
5	364.76	43.28	-561.29	670.80	364.76	43.28	-728.71	816.06	167.42

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.70	.79	-64.08	-67.44	555.85	506.63	19.365	13.999	1.5182	2.1002
2	.68	.79	-62.47	-66.48	554.33	507.14	19.235	14.088	1.5285	2.0869
3	.65	.76	-61.07	-65.76	554.80	511.90	19.427	14.733	1.5133	1.9955
4	.61	.74	-58.75	-64.45	553.71	515.15	19.619	15.238	1.4986	1.9294
5	.60	.73	-56.99	-63.41	553.36	515.92	19.651	15.377	1.4961	1.9119

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	570.52	24.169	1.7
2	570.41	24.250	1.7
3	571.04	24.440	1.7
4	570.89	24.566	1.6
5	571.33	24.754	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	5000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.1002	1.5182	.3115	.5291	93.2818	.1035	-.1186
2	2.0869	1.5285	.3274	.5437	78.4130	.1129	-.0021
3	1.9955	1.5133	.3496	.5610	65.4437	.1236	.0439
4	1.9294	1.4986	.3686	.5782	54.2298	.1358	.1241
5	1.9119	1.4961	.3769	.5859	47.9336	.1444	.2098

MASS AVERAGED QUANTITIES

HORSE POWER = 50.34 (HP)
MOMENT = 52.88 (FT-LB)
FLOW RATE = 4.02 (LB/SEC)

REFERRED RPM = 4682.79
REFERRED HORSE POWER = 23.58 (HP)
REFERRED MOMENT = 26.44 (FT-LB)
REFERRED FLOW RATE = 2.15 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .3475
TOTAL/TOTAL EFFICIENCY= .5601
TOTAL/STATIC PRESSURE RATIO = 2.0045
TOTAL/TOTAL PRESSURE RATIO = 1.5119

HEAD COEFFICIENT = 67.1736
BLADE/JET SPEED RATIO = .1220
THEORETICAL DEGREE OF REACTION= .0529
MACH NUMBER AT STATION 0 = .2146

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	10000.0	2.000	29.400	591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1048	.9122	.0878	.0878	0.0000
2	3.003	.940	0.0000	.2347	1.0481	.9056	.0944	.0944	.2519
3	3.195	1.000	.0290	.2526	1.0000	.9002	.0998	.0998	.4711
4	3.432	1.074	0.0000	.2745	.9394	.8957	.1043	.1043	.7554
5	3.627	1.135	0.0000	.2926	.8895	.8921	.1079	.1079	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	430.56	-17.27	951.13	1044.19	430.56	-17.27	709.93	830.47	241.21
2	408.48	3.88	892.34	981.40	408.48	3.88	630.27	751.08	262.07
3	394.59	8.92	843.80	929.50	394.59	8.92	564.94	689.16	278.86
4	366.11	31.80	786.31	867.95	366.11	31.80	406.84	609.97	299.47
5	346.65	41.13	739.61	817.85	346.65	41.13	423.09	540.51	316.52

STREAM LINE	MACH NUMBER ABSOLUTE	MACH NUMBER RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	FLOW ANGLE (DEG) RELATIVE	TEMPERATURE (DEG. R) TOTAL	TEMPERATURE (DEG. R) STATIC	PRESSURE (PSI) TOTAL	PRESSURE (PSI) STATIC	PRESSURE RATIO TOT/TOT	PRESSURE RATIO TOT/STA
1	.95	.76	65.65	58.77	591.01	500.28	27.643	15.426	1.0636	1.9059
2	.89	.68	65.41	57.06	591.01	510.86	27.750	16.663	1.0594	1.7644
3	.83	.62	65.21	55.07	591.01	519.12	27.850	17.688	1.0557	1.6622
4	.77	.54	65.04	53.06	591.01	528.32	28.003	18.914	1.0499	1.5544
5	.72	.48	64.89	50.67	591.01	535.35	28.126	19.896	1.0453	1.4777

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	10000.0	2.000	29.400	591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9767	.8273	.1727	.1727	0.0000
2	3.020	.925	-.0168	.2218	.9818	.8274	.1726	.1726	.2366
3	3.265	1.000	-.0405	.2447	1.0000	.8275	.1725	.1725	.4377
4	3.585	1.098	-.1537	.2747	1.0531	.8322	.1678	.1678	.7312
5	3.837	1.175	-.2100	.2983	1.1159	.8359	.1641	.1641	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	325.69	-13.06	-548.77	638.28	325.69	-13.06	-783.78	848.86	235.01
2	327.40	3.11	-488.54	588.10	327.40	3.11	-752.07	820.25	263.54
3	333.47	7.63	-455.53	564.59	333.47	7.63	-740.45	812.11	284.93
4	351.18	30.50	-421.45	549.43	351.18	30.50	-734.33	814.56	312.08
5	372.11	44.15	-408.55	554.38	372.11	44.15	-743.40	832.50	334.84

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.58	.78	-59.32	-67.44	531.37	497.47	17.424	13.833	1.6874	[illegible]
2	.54	.75	-56.18	-66.48	530.66	501.88	17.529	14.421	1.6772	[illegible]
3	.51	.74	-53.80	-65.76	530.25	504.04	17.580	14.722	1.6723	1.9970
4	.50	.74	-50.20	-64.45	529.88	504.76	17.674	14.911	1.6634	1.9717
5	.50	.76	-47.68	-63.41	529.28	503.71	17.655	14.846	1.6652	1.9804

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	557.43	22.524	1.6
2	557.87	22.675	1.6
3	559.92	22.907	1.6
4	559.97	23.185	1.6
5	561.38	23.492	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.1253	1.6874	.5208	.7269	23.6556	.2056	.1315
2	2.0386	1.6772	.5545	.7434	19.0412	.2292	.1667
3	1.9970	1.6723	.5734	.7525	16.3763	.2471	.2463
4	1.9717	1.6634	.5867	.7644	13.9628	.2676	.3284
5	1.9884	1.6652	.5889	.7704	12.5727	.2820	.4047

MASS AVERAGED QUANTITIES

HORSE POWER	=	81.03	(HP)
MOMENT	=	42.56	(FT-LB)
FLOW RATE	=	3.93	(LB/SEC)
REFERRED RPM	=	9365.59	
REFERRED HORSE POWER	=	37.95	(HP)
REFERRED MOMENT	=	21.20	(FT-LB)
REFERRED FLOW RATE	=	2.10	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.5674	
TOTAL/TOTAL EFFICIENCY	=	.7522	
TOTAL/STATIC PRESSURE RATIO	=	2.0150	
TOTAL/TOTAL PRESSURE RATIO	=	1.6723	
HEAD COEFFICIENT	=	16.8736	
BLADE/JET SPEED RATIO	=	.2434	
THEORETICAL DEGREE OF REACTION	=	.2574	
MACH NUMBER AT STATION 0	=	.2093	

SET NUMBER	PAGE NUMBER	RPM	IDIAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	15000.0	2.000	29.400	591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1015	.9061	.0939	.0939	0.0000
2	3.003	.940	0.0000	.2347	1.0467	.9022	.0978	.0978	.2534
3	3.195	1.000	.0290	.2526	1.0000	.8990	.1010	.1010	.4729
4	3.432	1.074	0.0000	.2745	.9413	.8989	.1011	.1011	.7566
5	3.627	1.135	0.0000	.2926	.8928	.8988	.1011	.1011	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	402.85	-16.16	889.91	976.98	402.85	-16.16	520.11	664.41	361.81
2	382.80	3.64	836.24	919.70	382.80	3.64	443.13	585.59	393.10
3	369.75	8.37	791.86	872.28	369.75	8.37	373.57	525.68	418.29
4	344.25	29.90	739.37	816.13	344.25	29.90	290.16	451.22	449.20
5	326.51	38.74	696.63	770.33	326.51	38.74	221.86	396.65	474.77

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.88	.60	65.65	52.67	591.01	511.58	27.778	16.762	1.0584	1.[illegible]549
2	.82	.52	65.41	49.18	591.01	520.63	27.919	17.912	1.0531	1.6413
3	.77	.47	65.21	45.30	591.01	527.70	28.036	18.857	1.0487	1.5591
4	.72	.40	65.04	40.13	591.01	535.59	28.220	19.993	1.0418	1.4705
5	.68	.35	64.89	34.20	591.01	541.63	28.358	20.896	1.0368	1.4070

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	15000.0	2.000	29.400	591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9831	.8557	.1443	.1443	0.0000
2	3.020	.925	-.0168	.2218	.9567	.8627	.1373	.1373	.2313
3	3.265	1.000	-.0405	.2447	1.0000	.8680	.1320	.1320	.4293
4	3.585	1.098	-.1537	.2747	1.0885	.8750	.1250	.1250	.7243
5	3.837	1.175	-.2100	.2983	1.1810	.8805	.1195	.1195	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	312.83	-12.55	-400.31	508.20	312.83	-12.55	-752.83	815.33	352.51
2	304.44	2.89	-304.04	430.27	304.44	2.89	-699.34	762.74	395.31
3	318.22	7.28	-279.21	423.41	318.22	7.28	-706.60	774.98	427.39
4	346.38	30.08	-254.97	431.15	346.38	30.08	-724.30	803.42	469.33
5	375.82	44.59	-248.55	452.78	375.82	44.59	-750.81	840.81	502.26

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.42	.75	-52.00	-67.44	513.94	492.45	15.931	13.719	1.8455	2.1441
2	.39	.70	-44.97	-66.48	516.30	500.89	16.478	14.821	1.7842	1.9847
3	.39	.71	-41.27	-65.76	516.03	501.35	16.529	14.942	1.7767	1.9676
4	.39	.73	-36.36	-64.45	515.82	500.35	16.604	14.926	1.7706	1.9697
5	.41	.77	-33.48	-63.41	515.19	498.13	16.574	14.731	1.7739	1.9958

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	547.77	21.291	1.6
2	549.31	21.610	1.5
3	551.33	21.982	1.5
4	554.07	22.513	1.5
5	556.96	23.039	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.1431	1.8455	.6664	.8120	10.6175	.3069	.2421
2	1.9837	1.7842	.7112	.8292	8.1692	.3499	.2573
3	1.9676	1.7787	.7216	.8363	7.1371	.3743	.3322
4	1.9697	1.7706	.7225	.8447	6.1975	.4017	.4075
5	1.9958	1.7739	.7160	.8493	5.6453	.4289	.4812

MASS AVERAGED QUANTITIES

HORSE POWER = 98.79 (HP)
MOMENT = 34.59 (FT-LB)
FLOW RATE = 3.86 (LB/SEC)

REFERRED RPM = 14048.38
REFERRED HORSE POWER = 46.26 (HP)
REFERRED MOMENT = 17.29 (FT-LB)
REFERRED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7116
TOTAL/TOTAL EFFICIENCY= .8352
TOTAL/STATIC PRESSURE RATIO = 1.9976
TOTAL/TOTAL PRESSURE RATIO = 1.7858

HEAD COEFFICIENT = 7.4088
BLADE/JET SPEED RATIO = .3674
THEORETICAL DEGREE OF REACTION= .3372
MACH NUMBER AT STATION 0 = .2057

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	2.000	29.400	591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1007	.9088	.0912	.0912	0.0000
2	3.003	.940	0.0000	.2347	1.0465	.9064	.0936	.0936	.2543
3	3.195	1.000	.0290	.2526	1.0000	.9045	.0955	.0955	.4742
4	3.432	1.074	0.0000	.2745	.9486	.9034	.0966	.0966	.7576
5	3.627	1.135	0.0000	.2926	.8914	.9024	.0976	.0976	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	392.34	-15.74	866.69	951.49	392.34	-15.74	384.28	549.41	482.41
2	373.02	3.54	814.87	896.20	373.02	3.54	290.73	472.95	524.14
3	361.55	8.16	771.71	850.09	361.55	8.16	213.99	420.21	557.72
4	335.27	29.12	720.07	794.83	335.27	29.12	121.13	357.67	598.94
5	317.71	37.69	677.85	749.56	317.71	37.69	44.82	323.06	633.03

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.85	.49	65.65	44.41	591.01	515.68	27.919	17.323	1.0530	1.6971
2	.80	.42	65.41	37.94	591.01	524.18	28.068	18.442	1.0475	1.5942
3	.75	.37	65.21	30.62	591.01	530.88	28.188	19.363	1.0430	1.5184
4	.70	.31	65.04	19.87	591.01	538.44	28.339	20.455	1.0374	1.4373
5	.66	.28	64.89	8.03	591.01	544.26	28.455	21.325	1.0332	1.3786

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	2.000	29.400	591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9898	.8838	.1162	.1162	0.0000
2	3.020	.925	-.0168	.2218	.9301	.8890	.1110	.1110	.2267
3	3.265	1.000	-.0405	.2447	1.0000	.8929	.1071	.1071	.4220
4	3.585	1.098	-.1537	.2747	1.1264	.8880	.1121	.1121	.7188
5	3.837	1.175	-.2100	.2983	1.2511	.8841	.1159	.1159	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	307.44	-12.33	-269.85	409.26	307.44	-12.33	-739.87	801.30	470.02
2	298.90	2.74	-136.58	319.57	298.90	2.74	-663.65	723.81	527.07
3	310.61	7.11	-119.86	333.02	310.61	7.11	-689.71	756.46	569.85
4	349.86	30.39	-105.81	366.78	349.86	30.39	-731.58	811.50	625.77
5	388.62	46.11	-106.70	405.63	388.62	46.11	-776.38	869.44	669.68

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.38	.74	-41.28	-67.44	500.32	486.38	14.810	13.416	1.9851	2.1914
2	.29	.66	-25.30	-66.48	507.95	499.45	15.898	14.986	1.8493	1.9618
3	.30	.69	-21.10	-65.76	508.01	499.89	15.942	14.984	1.8442	1.9621
4	.34	.74	-16.83	-64.45	508.22	497.02	15.910	14.717	1.8479	1.9977
5	.37	.80	-15.35	-63.41	507.71	494.81	15.752	14.324	1.8652	2.0525

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	539.81	28.331	1.5
2	543.05	20.872	1.4
3	546.71	21.460	1.4
4	551.82	22.289	1.5
5	556.92	23.112	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.1914	1.9851	.7642	.8625	6.1204	.4039	.3015
2	1.9618	1.8493	.8025	.8724	4.5275	.4700	.2876
3	1.9621	1.8442	.8017	.8754	3.9997	.5000	.3578
4	1.9977	1.8479	.7810	.8706	3.5516	.5306	.4511
5	2.0525	1.8652	.7590	.8640	3.2914	.5512	.5280

MASS AVERAGED QUANTITIES

HORSE POWER	=	109.74	(HP)
MOMENT	=	28.82	(FT-LB)
FLOW RATE	=	3.85	(LB/SEC)
REFERRED RPM	=	18731.18	
REFERRED HORSE POWER	=	51.39	(HP)
REFERRED MOMENT	=	14.41	(FT-LB)
REFERRED FLOW RATE	=	2.06	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7067	
TOTAL/TOTAL EFFICIENCY	=	.8704	
TOTAL/STATIC PRESSURE RATIO	=	2.0109	
TOTAL/TOTAL PRESSURE RATIO	=	1.8666	
HEAD COEFFICIENT	=	4.1972	
BLADE/JET SPEED RATIO	=	.4881	
THEORETICAL DEGREE OF REACTION	=	.3778	
MACH NUMBER AT STATION 0	=	.2052	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	25000.0	2.000	29.400	591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1023	.9134	.0866	.0866	0.0000
2	3.003	.940	0.0000	.2347	1.0472	.9101	.0899	.0899	.2553
3	3.195	1.000	.0270	.2526	1.0000	.9075	.0925	.0925	.4754
4	3.432	1.074	0.0000	.2745	.9401	.9058	.0942	.0942	.7584
5	3.627	1.135	0.0000	.2926	.8904	.9044	.0956	.0956	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	386.00	-15.48	852.69	936.12	386.00	-15.48	249.68	459.98	603.01
2	366.71	3.48	801.07	881.02	366.71	3.48	145.90	394.68	655.17
3	350.19	8.01	758.19	835.20	350.19	8.01	61.04	355.56	697.15
4	329.20	28.59	707.04	780.45	329.20	28.59	-41.63	333.05	748.67
5	311.83	37.00	665.30	735.68	311.83	37.00	-125.99	338.35	791.29

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.84	.41	65.65	32.90	591.01	518.09	28.049	17.691	1.0482	1.5619
2	.78	.35	65.41	21.70	591.01	526.42	28.171	18.789	1.0436	1.5648
3	.74	.31	65.21	9.89	591.01	532.97	28.273	19.690	1.0399	1.4932
4	.68	.29	65.04	-7.21	591.01	540.33	28.408	20.757	1.0349	1.4164
5	.64	.30	64.89	-22.00	591.01	545.97	28.512	21.605	1.0311	1.3608

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	25000.0	2.000	29.400	591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9982	.9019	.0981	.0981	0.0000
2	3.020	.925	-.0168	.2218	.9020	.8912	.1089	.1089	.2209
3	3.265	1.000	-.0405	.2447	1.0000	.8831	.1170	.1170	.4114
4	3.585	1.098	-.1537	.2747	1.1673	.8861	.1139	.1139	.7094
5	3.837	1.175	-.2100	.2983	1.3260	.8885	.1115	.1115	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	300.44	-12.05	-135.50	329.81	300.44	-12.05	-723.03	783.06	537.52
2	271.49	2.58	35.19	273.78	271.49	2.58	-623.66	680.19	658.84
3	301.00	6.89	43.96	304.27	301.00	6.89	-668.36	733.04	712.31
4	351.34	30.51	47.55	355.85	351.34	30.51	-734.67	814.93	78[illegible]
5	399.12	47.35	39.75	403.88	399.12	47.35	-797.35	892.92	837.11

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.31	.73	-24.28	-67.44	492.19	483.14	14.198	13.305	2.0707	2.2097
2	.25	.62	7.39	-66.48	507.52	501.20	15.995	15.318	1.8381	1.9194
3	.28	.67	8.31	-65.76	508.25	500.55	15.995	15.162	1.8381	1.9350
4	.33	.74	7.71	-64.45	509.10	498.57	16.028	14.896	1.8343	1.9737
5	.37	.82	5.69	-63.41	508.94	495.36	15.922	14.484	1.8465	2.0298

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	534.16	19.687	1.5
2	539.78	20.512	1.3
3	545.26	21.326	1.4
4	553.83	22.629	1.5
5	561.71	23.864	1.6

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.2097	2.0707	.8249	.8905	3.9591	.5026	.3335
2	1.9194	1.8381	.8312	.8850	2.8121	.5963	.2934
3	1.9390	1.8381	.8124	.8772	2.5189	.6301	.3721
4	1.9737	1.8343	.7850	.8708	2.2371	.6686	.4637
5	2.0298	1.8465	.7584	.8640	2.0771	.6939	.5399

MASS AVERAGED QUANTITIES

HORSE POWER	=	108.40	(HP)
MOMENT	=	22.79	(FT-LB)
FLOW RATE	=	3.77	(LB/SEC)
REFERRED RPM	=	23413.97	
REFERRED HORSE POWER	=	50.80	(HP)
REFERRED MOMENT	=	11.40	(FT-LB)
REFERRED FLOW RATE	=	2.02	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.8051	
TOTAL/TOTAL EFFICIENCY	=	.8776	
TOTAL/STATIC PRESSURE RATIO	=	1.9879	
TOTAL/TOTAL PRESSURE RATIO	=	1.8673	
HEAD COEFFICIENT	=	2.6465	
BLADE/JET SPEED RATIO	=	.6147	
THEORETICAL DEGREE OF REACTION	=	.3915	
MACH NUMBER AT STATION 8	=	.2016	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	30000.0	2.000	29.400	591.01

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1043	.9201	.0799	.0799	0.0000
2	3.003	.940	0.0000	.2347	1.0480	.9156	.0844	.0844	.2548
3	3.195	1.000	.0290	.2526	1.0000	.9119	.0881	.0881	.4748
4	3.432	1.074	0.0000	.2745	.9393	.9095	.0905	.0905	.7580
5	3.627	1.135	0.0000	.2926	.8893	.9075	.0925	.0925	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	397.01	-15.93	877.82	962.83	397.01	-15.93	153.40	425.92	723.62
2	376.77	3.58	823.06	905.21	376.77	3.58	36.85	378.59	786.21
3	352.11	8.23	778.40	857.45	352.11	8.23	-58.18	356.98	836.58
4	337.72	29.33	725.33	800.63	337.72	29.33	-173.08	380.62	898.41
5	319.71	37.93	682.12	754.28	319.71	37.93	-267.43	418.53	949.55

STREAM LINE	MACH NUMBER ABSOLUTE	MACH NUMBER RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	FLOW ANGLE (DEG) RELATIVE	TEMPERATURE (DEG. R) TOTAL	TEMPERATURE (DEG. R) STATIC	PRESSURE (PSI) TOTAL	PRESSURE (PSI) STATIC	PRESSURE RATIO TOT/TOT	PRESSURE RATIO TOT/STA
1	.87	.38	65.65	21.13	591.01	513.87	28.080	17.211	1.0470	1.7082
2	.81	.34	65.41	5.59	591.01	522.83	28.181	18.349	1.0433	1.6022
3	.76	.32	65.21	-9.38	591.01	529.83	28.268	19.284	1.0400	1.5246
4	.70	.33	65.04	-27.14	591.01	537.67	28.397	20.394	1.0353	1.4416
5	.66	.37	64.89	-39.91	591.01	543.67	28.497	21.276	1.0317	1.3819

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	30000.0	2.000	29.400	591.01

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0060	.9114	.0886	.0886	0.0000
2	3.020	.925	-.0168	.2218	.8756	.8932	.1069	.1069	.2130
3	3.265	1.000	-.0405	.2447	1.0000	.8795	.1206	.1206	.3983
4	3.585	1.098	-.1537	.2747	1.2080	.8912	.1089	.1089	.6982
5	3.837	1.175	-.2100	.2983	1.4017	.9004	.0997	.0997	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	297.96	-11.95	-12.01	298.44	297.96	-11.95	-717.04	776.57	705.03
2	259.34	2.46	194.87	324.40	259.34	2.46	-595.75	649.75	790.61
3	296.19	6.78	197.09	355.84	296.19	6.78	-657.69	721.34	854.78
4	357.80	31.08	190.49	406.53	357.80	31.08	-748.16	829.90	938.65
5	415.16	49.26	175.12	453.27	415.16	49.26	-829.40	928.81	1004.53

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.28	.73	-2.31	-67.44	483.98	476.57	13.461	12.753	2.1841	2.3053
2	.30	.59	36.92	-66.48	508.96	500.20	16.215	15.260	1.8131	1.9267
3	.32	.66	33.64	-65.76	510.67	499.70	16.257	15.067	1.8084	1.9513
4	.37	.76	28.03	-64.45	512.32	498.57	16.390	14.901	1.7938	1.9730
5	.42	.85	22.87	-63.41	512.49	495.40	16.351	14.520	1.7981	2.0248

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	526.75	18.769	1.5
2	535.33	19.932	1.3
3	543.00	21.014	1.4
4	555.88	22.915	1.5
5	567.18	24.675	1.7

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.000	29.400	591.01

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.3053	2.1841	.8531	.9053	2.8795	.5893	.3317
2	1.9267	1.8131	.8126	.8888	1.9632	.7137	.2625
3	1.9513	1.8084	.7819	.8730	1.7644	.7528	.3471
4	1.9730	1.7938	.7545	.8660	1.5528	.8025	.4377
5	2.0240	1.7981	.7278	.8608	1.4379	.8339	.5164

MASS AVERAGED QUANTITIES

HORSE POWER = 105.42 (HP)
MOMENT = 18.46 (FT-LB)
FLOW RATE = 3.75 (LB/SEC)

REFERRED RPM = 28096.77
REFERRED HORSE POWER = 49.37 (HP)
REFERRED MOMENT = 9.23 (FT-LB)
REFERRED FLOW RATE = 2.00 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7849
TOTAL/TOTAL EFFICIENCY= .8775
TOTAL/STATIC PRESSURE RATIO = 2.0040
TOTAL/TOTAL PRESSURE RATIO = 1.8516

HEAD COEFFICIENT = 1.8598
BLADE/JET SPEED RATIO = .7333
THEORETICAL DEGREE OF REACTION= .3678
MACH NUMBER AT STATION 0 = .1995

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	15000.0	2.200	32.340	603.60

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1032	.9106	.0894	.0894	0.0000
2	3.003	.940	0.0000	.2347	1.0473	.9052	.0948	.0948	.2520
3	3.195	1.000	.0298	.2526	1.0000	.9008	.0992	.0992	.4710
4	3.432	1.074	0.0000	.2745	.9408	.9002	.0998	.0998	.7552
5	3.627	1.135	0.0000	.2926	.8920	.8996	.1004	.1004	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	427.56	-17.15	944.51	1036.92	427.56	-17.15	582.70	722.94	361.81
2	405.92	3.86	886.73	975.24	405.92	3.86	493.63	639.11	393.10
3	387.58	8.87	839.15	924.37	387.58	8.87	420.86	572.20	418.29
4	364.63	31.67	783.13	864.44	364.63	31.67	333.93	495.44	449.20
5	345.74	41.02	737.65	815.69	345.74	41.02	262.88	436.26	474.77

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.93	.65	65.65	53.73	603.60	514.13	30.446	17.365	1.0622	1.8624
2	.87	.57	65.41	50.57	603.60	524.46	30.586	18.702	1.0574	1.7292
3	.82	.51	65.21	47.36	603.60	532.50	30.707	19.803	1.0532	1.6331
4	.76	.43	65.04	42.49	603.60	541.42	30.921	21.135	1.0459	1.5302
5	.71	.38	64.89	37.25	603.60	548.24	31.082	22.196	1.0405	1.4570

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	15000.0	2.200	32.340	603.60

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9817	.8565	.1436	.1436	0.0000
2	3.020	.925	-.0168	.2218	.9631	.8624	.1376	.1376	.2317
3	3.265	1.000	-.0405	.2447	1.0000	.8669	.1331	.1331	.4304
4	3.585	1.098	-.1537	.2747	1.0807	.8754	.1247	.1247	.7254
5	3.837	1.175	-.2100	.2983	1.1669	.8820	.1180	.1180	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	340.83	-13.67	-467.70	578.87	340.83	-13.67	-820.21	888.31	352.51
2	334.38	3.18	-372.80	500.80	334.38	3.18	-768.11	837.74	395.31
3	347.19	7.94	-343.55	488.50	347.19	7.94	-770.93	845.55	427.39
4	375.22	32.59	-315.28	491.18	375.22	32.59	-784.61	870.33	469.33
5	405.14	48.07	-307.12	510.66	405.14	48.07	-809.38	906.39	502.26

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.53	.82	-53.92	-67.44	519.29	491.41	16.612	13.694	1.9468	2.3617
2	.46	.76	-48.11	-66.48	521.06	500.19	17.117	14.835	1.8893	2.1799
3	.45	.77	-44.70	-65.76	520.75	500.89	17.172	14.988	1.8833	2.1578
4	.45	.79	-40.04	-64.45	520.43	500.35	17.274	15.052	1.8722	2.1486
5	.47	.83	-37.17	-63.41	519.64	497.94	17.246	14.854	1.8752	2.1772

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	557.07	22.993	1.7
2	558.59	23.320	1.6
3	560.38	23.676	1.6
4	563.38	24.291	1.6
5	566.31	24.864	1.7

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.200	32.340	603.60

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.3617	1.9468	.6416	.8059	12.0635	.2879	.2523
2	2.1799	1.8893	.6851	.8227	9.3694	.3267	.2743
3	2.1578	1.8833	.6958	.8297	8.1781	.3497	.3371
4	2.1486	1.8722	.7020	.8400	7.0560	.3765	.4170
5	2.1772	1.8752	.6979	.8460	6.4139	.3949	.4884

MASS AVERAGED QUANTITIES

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                HORSE POWER =    118.32   (HP)
                MOMENT      =     41.43   (FT-LB)
                FLOW RATE   =      4.19   (LB/SEC)

       REFERRED  RPM        =  13901.10
       REFERRED HORSE POWER =     49.84   (HP)
       REFERRED MOMENT      =     18.83   (FT-LB)
       REFERRED FLOW RATE   =      2.05   (LB/SEC)

    TOTAL/STATIC EFFICIENCY =     .6882
     TOTAL/TOTAL  EFFICIENCY=     .8296
  TOTAL/STATIC PRESSURE RATIO =  2.1889
  TOTAL/TOTAL  PRESSURE RATIO =  1.8890

HEAD COEFFICIENT                =  8.4606
BLADE/JET SPEED RATIO           =   .3438
THEORETICAL DEGREE OF REACTION=     .3497
MACH NUMBER AT STATION 0        =   .2049
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SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	2.200	32.340	603.60

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1014	.9111	.0889	.0889	0.0000
2	3.003	.940	0.0000	.2347	1.0468	.9081	.0919	.0919	.2530
3	3.195	1.000	.0290	.2526	1.0000	.9057	.0943	.0943	.4724
4	3.432	1.074	0.0000	.2745	.9405	.9045	.0955	.0955	.7564
5	3.627	1.135	0.0000	.2926	.8912	.9035	.0965	.0965	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	414.03	-16.61	914.61	1004.10	414.03	-16.61	432.20	598.75	482.41
2	393.50	3.74	859.60	945.39	393.50	3.74	335.46	517.10	524.14
3	381.15	8.60	813.88	896.54	381.15	8.60	256.16	459.31	557.72
4	353.54	30.71	759.31	838.14	353.54	30.71	160.37	389.42	598.94
5	335.01	39.75	714.75	790.37	335.01	39.75	81.72	347.11	633.03

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.90	.54	65.65	46.23	603.60	519.70	30.592	18.119	1.0572	1.7849
2	.84	.46	65.41	40.45	603.60	529.23	30.759	19.413	1.0514	[illegible]
3	.79	.40	65.21	33.91	603.60	536.72	30.896	20.483	1.0467	[illegible]
4	.73	.34	65.04	24.40	603.60	545.15	31.077	21.757	1.0407	1.4864
5	.69	.30	64.89	13.71	603.60	551.62	31.215	22.776	1.0360	1.4199

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	2.200	32.340	603.60

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9876	.8852	.1148	.1148	0.0000
2	3.020	.925	-.0168	.2218	.9391	.8896	.1104	.1104	.2272
3	3.265	1.000	-.0405	.2447	1.0000	.8929	.1071	.1071	.4235
4	3.585	1.098	-.1537	.2747	1.1131	.8986	.1014	.1014	.7201
5	3.837	1.175	-.2100	.2983	1.2264	.9030	.0970	.0970	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	338.22	-13.57	-343.92	482.56	338.22	-13.57	-813.94	881.52	470.02
2	321.59	3.06	-211.66	385.01	321.59	3.06	-738.74	805.71	527.07
3	342.46	7.84	-190.57	391.99	342.46	7.84	-760.42	834.01	569.85
4	381.20	33.11	-171.35	419.25	381.20	33.11	-797.11	884.20	625.77
5	419.97	49.83	-169.33	455.56	419.97	49.83	-839.02	939.58	669.68

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.45	.82	-45.48	-67.44	503.27	483.89	15.230	13.274	2.1235	[illegible]
2	.35	.74	-33.35	-66.48	510.05	497.72	16.270	14.934	1.9877	[illegible]
3	.36	.76	-29.10	-65.76	509.98	497.53	16.307	14.955	[illegible]	[illegible]
4	.38	.81	-24.20	-64.45	510.07	495.44	16.361	14.777	1.9766	[illegible]
5	.42	.86	-21.96	-63.41	509.43	492.16	16.291	14.439	1.9851	2.2398

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	548.55	21.890	1.6
2	551.73	22.460	1.5
3	555.41	23.090	1.5
4	560.50	23.979	1.6
5	565.62	24.864	1.7

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	2.200	32.340	603.60

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	TOT/TOT	EFFICIENCY TOT/STA	TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.4363	2.1235	.7400	.8587	7.0014	.3779	.3208
2	2.1655	1.9877	.7824	.8697	5.2302	.4373	.3150
3	2.1625	1.9832	.7842	.8729	4.6118	.4657	.3814
4	2.1885	1.9766	.7728	.8759	4.0543	.4966	.4660
5	2.2398	1.9851	.7582	.8770	3.7248	.5181	.5368

MASS AVERAGED QUANTITIES

HORSE POWER =	136.30	(HP)
MOMENT =	35.79	(FT-LB)
FLOW RATE =	4.25	(LB/SEC)
REFERRED RPM =	18534.80	
REFERRED HORSE POWER =	57.42	(HP)
REFERRED MOMENT =	16.27	(FT-LB)
REFERRED FLOW RATE =	2.09	(LB/SEC)
TOTAL/STATIC EFFICIENCY =	.7722	
TOTAL/TOTAL EFFICIENCY=	.8716	
TOTAL/STATIC PRESSURE RATIO =	2.2132	
TOTAL/TOTAL PRESSURE RATIO =	2.0005	
HEAD COEFFICIENT =	4.8149	
BLADE/JET SPEED RATIO =	.4557	
THEORETICAL DEGREE OF REACTION=	.3978	
MACH NUMBER AT STATION 0 =	.2082	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	25000.0	2.200	32.340	603.60

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1029	.9153	.0847	.0847	0.0000
2	3.003	.940	0.0000	.2347	1.0474	.9115	.0885	.0885	.2543
3	3.195	1.000	.0290	.2526	1.0000	.9084	.0916	.0916	.4741
4	3.432	1.074	0.0000	.2745	.9399	.9067	.0933	.0933	.7575
5	3.627	1.135	0.0000	.2926	.8903	.9053	.0947	.0947	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	403.36	-16.18	891.84	978.22	403.36	-16.18	288.03	495.90	603.01
2	383.07	3.64	836.81	920.33	383.07	3.64	181.64	423.97	655.17
3	365.73	8.37	791.85	872.27	365.73	8.37	94.70	377.89	697.15
4	343.77	29.86	738.33	814.99	343.77	29.86	-10.34	345.22	748.67
5	325.61	38.63	694.71	768.20	325.61	38.63	-96.58	341.82	791.29

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.87	.44	65.65	35.53	603.60	523.97	30.776	18.757	1.0508	1.7241
2	.81	.37	65.41	25.37	603.60	533.12	30.910	20.015	1.0463	1.6158
3	.77	.33	65.21	14.52	603.60	540.29	31.023	21.050	1.0425	1.5364
4	.71	.30	65.04	-1.72	603.60	548.33	31.181	22.280	1.0372	1.4515
5	.67	.30	64.89	-16.52	603.60	554.49	31.303	23.260	1.0331	1.3904

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	25000.0	2.200	32.340	603.60

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9947	.9031	.0969	.0969	0.0000
2	3.020	.925	-.0168	.2218	.9138	.9049	.0951	.0951	.2222
3	3.265	1.000	-.0405	.2447	1.0000	.9062	.0938	.0938	.4165
4	3.585	1.098	-.1537	.2747	1.1508	.8981	.1019	.1019	.7149
5	3.837	1.175	-.2100	.2983	1.2961	.8918	.1083	.1083	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	331.43	-13.29	-210.08	392.63	331.43	-13.29	-797.60	863.82	587.52
2	304.47	2.89	-40.56	307.17	304.47	2.89	-699.40	762.81	658.84
3	333.18	7.62	-27.51	334.41	333.18	7.62	-739.83	811.43	712.31
4	383.43	33.30	-19.55	385.37	383.43	33.30	-801.76	809.36	782.21
5	431.85	51.24	-25.64	435.64	431.85	51.24	-862.75	966.15	837.11

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.37	.80	-32.37	-67.44	493.64	480.81	14.498	13.222	2.2307	2.4460
2	.28	.70	-7.59	-66.48	507.91	500.06	16.300	15.435	1.9841	2.0953
3	.31	.74	-4.72	-65.76	508.47	499.16	16.353	15.330	1.9776	2.1096
4	.35	.81	-2.92	-64.45	509.06	496.70	16.290	14.948	1.9852	2.1635
5	.40	.89	-3.40	-63.41	508.54	492.75	16.059	14.381	2.0138	2.2488

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	542.90	21.238	1.6
2	548.48	22.107	1.4
3	553.95	22.972	1.5
4	562.52	24.364	1.6
5	570.42	25.684	1.8

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	2.200	32.340	603.60

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.4460	2.2307	.8029	.8893	4.4985	.4215	.3409
2	2.0953	1.9841	.8322	.8917	3.2191	.5574	.3275
3	2.1896	1.9776	.8206	.8904	2.8666	.5906	.3989
4	2.1635	1.9852	.7916	.8803	2.5607	.6249	.4096
5	2.2488	2.0138	.7620	.8680	2.3944	.6462	.5652

MASS AVERAGED QUANTITIES

HORSE POWER	=	137.41	(HP)
MOMENT	=	29.87	(FT-LB)
FLOW RATE	=	4.18	(LB/SEC)
REFERRED RPM	=	23168.50	
REFERRED HORSE POWER	=	57.88	(HP)
REFERRED MOMENT	=	13.12	(FT-LB)
REFERRED FLOW RATE	=	2.05	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.8073	
TOTAL/TOTAL EFFICIENCY	=	.8854	
TOTAL/STATIC PRESSURE RATIO	=	2.1790	
TOTAL/TOTAL PRESSURE RATIO	=	2.0173	
HEAD COEFFICIENT	=	3.0232	
BLADE/JET SPEED RATIO	=	.5751	
THEORETICAL DEGREE OF REACTION	=	.4198	
MACH NUMBER AT STATION 0	=	.2047	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	30000.0	2.200	32.340	603.60

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA./VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1037	.9179	.0821	.0821	0.0000
2	3.003	.940	0.0000	.2347	1.0477	.9136	.0864	.0864	.2545
3	3.195	1.000	.0290	.2526	1.0000	.9102	.0898	.0098	.4743
4	3.432	1.074	0.0000	.2745	.9396	.9081	.0919	.0919	.7577
5	3.627	1.135	0.0000	.2926	.8898	.9065	.0935	.0935	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	403.41	-16.18	891.15	978.34	403.41	-16.18	167.54	437.11	723.62
2	382.94	3.64	836.55	920.04	382.94	3.64	50.34	386.25	786.21
3	370.16	8.36	791.33	871.70	370.16	8.36	-45.25	373.01	836.58
4	343.44	29.83	737.61	814.19	343.44	29.83	-160.80	380.39	898.41
5	325.22	38.58	693.87	767.27	325.22	38.58	-255.68	415.48	949.55

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.87	.39	65.65	22.55	603.60	523.95	30.828	18.787	1.0490	1.7214
2	.81	.34	65.41	7.49	603.60	533.16	30.948	20.046	1.0450	1.6133
3	.76	.33	65.21	-6.97	603.60	540.37	31.052	21.081	1.0415	1.5341
4	.71	.33	65.04	-25.09	603.60	548.44	31.203	22.311	1.0364	1.4495
5	.66	.36	64.89	-38.18	603.60	554.61	31.320	23.290	1.0326	1.3006

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	30000.0	2.200	32.340	603.60

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0024	.9152	.0849	.0849	0.0000
2	3.020	.925	-.0168	.2218	.8883	.8969	.1032	.1032	.2166
3	3.265	1.000	-.0405	.2447	1.0000	.8831	.1169	.1169	.4058
4	3.585	1.098	-.1537	.2747	1.1837	.8931	.1069	.1069	.7051
5	3.837	1.175	-.2100	.2983	1.3551	.9010	.0991	.0991	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	331.81	-13.31	-93.49	344.99	331.81	-13.31	-798.52	864.82	705.03
2	294.85	2.79	115.13	315.80	294.05	2.79	-675.48	736.72	790.61
3	331.02	7.57	119.75	352.10	331.02	7.57	-735.03	806.16	854.78
4	391.84	34.03	119.31	411.01	391.84	34.03	-819.34	908.65	938.65
5	448.58	53.22	108.37	464.54	448.58	53.22	-896.16	1003.57	1004.53

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.32	.81	-15.74	-67.44	485.31	475.41	13.767	12.808	2.3491	2.5249
2	.29	.67	21.38	-66.48	509.29	500.99	16.465	15.545	1.9642	2.0805
3	.32	.74	19.89	-65.76	510.46	500.43	16.422	15.320	1.9693	2.1109
4	.38	.83	16.94	-64.45	511.95	497.90	16.541	15.005	1.9552	2.1553
5	.43	.92	13.58	-63.41	512.07	494.11	16.490	14.553	1.9612	2.2222

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	537.64	20.561	1.6
2	546.16	21.808	1.4
3	554.51	23.075	1.5
4	566.63	25.011	1.7
5	577.92	26.899	1.8

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.200	32.340	603.60

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.5249	2.3491	.8429	.9051	3.2209	.5572	.3017
2	2.0805	1.9642	.8273	.8907	2.2162	.6717	.3237
3	2.1189	1.9693	.8028	.8766	1.9922	.7085	.4012
4	2.1553	1.9552	.7707	.8710	1.7704	.7516	.4892
5	2.2222	1.9612	.7434	.8663	1.6410	.7806	.5611

MASS AVERAGED QUANTITIES

HORSE POWER	=	136.86	(HP)
MOMENT	=	23.96	(FT-LB)
FLOW RATE	=	4.22	(LB/SEC)
REFERRED RPM	=	27802.20	
REFERRED HORSE POWER	=	57.65	(HP)
REFERRED MOMENT	=	10.89	(FT-LB)
REFERRED FLOW RATE	=	2.07	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.7985	
TOTAL/TOTAL EFFICIENCY	=	.8810	
TOTAL/STATIC PRESSURE RATIO	=	2.1801	
TOTAL/TOTAL PRESSURE RATIO	=	2.0110	
HEAD COEFFICIENT	=	2.1024	
BLADE/JET SPEED RATIO	=	.6897	
THEORETICAL DEGREE OF REACTION	=	.4214	
MACH NUMBER AT STATION 0	=	.2068	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	10000.0	2.400	35.280	615.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1059	.9195	.0805	.0805	0.0000
2	3.003	.940	0.0000	.2347	1.0486	.9125	.0875	.0875	.2499
3	3.195	1.000	.0290	.2526	1.0000	.9068	.0932	.0932	.4680
4	3.432	1.074	0.0000	.2745	.9387	.9015	.0985	.0985	.7531
5	3.627	1.135	0.0000	.2926	.8883	.8972	.1028	.1028	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	473.88	-19.01	1046.83	1149.25	473.88	-19.01	805.62	934.85	241.21
2	449.34	4.27	981.58	1079.55	449.34	4.27	719.52	848.31	262.07
3	428.49	9.80	927.73	1021.95	428.49	9.80	648.87	777.65	278.86
4	402.24	34.94	863.90	953.59	402.24	34.94	564.43	693.97	299.47
5	380.61	45.16	812.86	897.97	380.61	45.16	495.54	626.47	316.52

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	1.04	.85	65.65	59.54	615.30	505.40	32.985	16.566	1.0696	2.1296
2	.97	.76	65.41	58.02	615.30	518.32	33.113	18.167	1.0654	1.9419
3	.91	.69	65.21	56.56	615.30	528.39	33.236	19.506	1.0615	1.8087
4	.84	.61	65.84	54.53	615.30	539.63	33.425	21.116	1.0555	1.6798
5	.78	.55	64.89	52.48	615.30	548.20	33.578	22.415	1.0507	1.5739

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	10000.0	2.400	35.280	615.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0718	.1912	.9754	.8379	.1621	.1621	0.0000
2	3.020	.925	-.0166	.2218	.9888	.8364	.1637	.1637	.2359
3	3.265	1.000	-.0405	.2447	1.0000	.8352	.1649	.1649	.4371
4	3.585	1.098	-.1537	.2747	1.0449	.8402	.1599	.1599	.7311
5	3.837	1.175	-.2100	.2983	1.1009	.8441	.1559	.1559	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	376.07	-15.09	-670.81	768.48	376.07	-15.09	-905.01	980.16	235.01
2	381.24	3.62	-612.23	721.24	381.24	3.62	-875.77	955.16	263.54
3	395.57	8.82	-571.23	689.23	385.57	8.82	-856.15	939.01	284.93
4	402.88	34.99	-529.56	666.31	402.88	34.99	-842.44	934.47	312.88
5	424.47	50.36	-513.15	667.86	424.47	50.36	-848.00	949.63	334.84

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.70	.90	-60.70	-67.44	547.07	497.93	19.575	14.081	1.8623	2.5054
2	.66	.87	-58.09	-66.48	545.64	502.35	19.576	14.658	1.8022	2.4968
3	.63	.85	-55.99	-65.76	545.16	505.63	19.654	15.102	1.7950	2.3361
4	.60	.85	-52.74	-64.45	544.67	507.73	19.805	15.488	1.7814	2.2779
5	.61	.86	-50.41	-63.41	543.93	506.81	19.792	15.455	1.7825	2.2828

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	577.87	26.481	1.9
2	578.27	26.647	1.8
3	579.00	26.865	1.8
4	580.39	27.245	1.8
5	581.85	27.612	1.8

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	10000.0	2.400	35.280	615.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.5054	1.8023	.4804	.7159	29.3338	.1846	.1584
2	2.4068	1.8022	.5182	.7310	23.8934	.2046	.2217
3	2.3361	1.7958	.5296	.7406	20.4693	.2210	.2764
4	2.2779	1.7814	.5477	.7548	17.2807	.2406	.3492
5	2.2828	1.7825	.5522	.7620	15.5053	.2540	.4214

MASS AVERAGED QUANTITIES

HORSE POWER =	109.48	(HP)
MOMENT =	57.50	(FT-LB)
FLOW RATE =	4.60	(LB/SEC)
REFERRED RPM =	9178.87	
REFERRED HORSE POWER =	41.87	(HP)
REFERRED MOMENT =	23.96	(FT-LB)
REFERRED FLOW RATE =	2.09	(LB/SEC)
TOTAL/STATIC EFFICIENCY =	.5259	
TOTAL/TOTAL EFFICIENCY=	.7413	
TOTAL/STATIC PRESSURE RATIO =	2.3537	
TOTAL/TOTAL PRESSURE RATIO =	1.7928	
HEAD COEFFICIENT =	21.8157	
BLADE/JET SPEED RATIO =	.2181	
THEORETICAL DEGREE OF REACTION=	.2843	
MACH NUMBER AT STATION 0 =	.2084	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	15000.0	2.400	35.280	615.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1043	.9122	.0878	.0878	0.0000
2	3.003	.940	0.0000	.2347	1.0477	.9056	.0944	.0944	.2515
3	3.195	1.000	.0290	.2526	1.0000	.9002	.0998	.0998	.4703
4	3.432	1.074	0.0000	.2745	.9408	.9000	.1000	.1000	.7546
5	3.627	1.135	0.0000	.2926	.8923	.8998	.1002	.1002	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	439.59	-17.63	971.07	1066.08	439.59	-17.63	609.26	751.50	361.81
2	417.04	3.96	911.03	1001.96	417.04	3.96	517.93	664.97	393.10
3	398.05	9.11	861.82	949.35	398.05	9.11	443.53	596.03	418.29
4	374.50	32.53	804.34	887.84	374.50	32.53	355.13	517.14	449.20
5	355.18	42.14	757.81	837.98	355.18	42.14	283.03	456.11	474.77

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.95	.67	65.65	54.19	615.30	520.73	33.169	18.496	1.0636	1.9075
2	.89	.59	65.41	51.16	615.30	531.76	33.299	19.982	1.0595	1.7656
3	.83	.52	65.21	48.10	615.30	540.30	33.417	21.203	1.0557	1.6639
4	.77	.45	65.04	43.48	615.30	549.71	33.670	22.693	1.0478	1.5547
5	.72	.39	64.89	38.55	615.30	556.87	33.858	23.877	1.0420	1.4775

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	15000.0	2.400	35.280	615.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9810	.8603	.1397	.1397	0.0000
2	3.020	.925	-.0168	.2218	.9666	.8647	.1354	.1354	.2320
3	3.265	1.000	-.0405	.2447	1.0000	.8679	.1321	.1321	.4312
4	3.585	1.098	-.1537	.2747	1.0753	.8761	.1239	.1239	.7262
5	3.837	1.175	-.2100	.2983	1.1567	.8825	.1175	.1175	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	361.69	-14.51	-517.91	631.88	361.69	-14.51	-870.43	942.70	352.51
2	356.38	3.39	-423.34	553.39	356.38	3.39	-818.65	892.66	395.31
3	368.69	8.44	-391.28	537.69	368.69	8.44	-818.67	897.20	427.39
4	396.46	34.43	-359.70	536.42	396.46	34.43	-829.02	919.59	479.33
5	426.46	50.60	-349.72	553.83	426.46	50.60	-851.98	954.10	502.26

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.58	.87	-55.07	-67.44	526.44	493.22	17.627	14.031	2.0014	2.5144
2	.50	.81	-49.91	-66.48	527.85	502.37	10.099	15.221	1.9494	2.3177
3	.49	.82	-46.71	-65.76	527.47	503.42	18.143	15.409	1.9445	2.2896
4	.49	.84	-42.22	-64.45	527.07	503.13	18.265	15.522	1.9316	2.2729
5	.50	.87	-39.36	-63.41	526.19	500.67	18.236	15.323	1.9347	2.3024

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	567.17	24.942	1.8
2	568.70	25.277	1.7
3	570.58	25.649	1.7
4	573.50	26.321	1.7
5	576.41	26.942	1.8

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.400	35.280	615.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.5144	2.0014	.6236	.8031	13.0814	.2765	.2725
2	2.3179	1.9493	.6657	.8186	10.2166	.3129	.2978
3	2.2896	1.9445	.6773	.8249	8.9067	.3351	.3576
4	2.2729	1.9316	.6857	.8363	7.6624	.3613	.4335
5	2.3024	1.9347	.6831	.8428	6.9546	.3792	.5022

MASS AVERAGED QUANTITIES

HORSE POWER	=	135.97	(HP)
MOMENT	=	47.61	(FT-LB)
FLOW RATE	=	4.54	(LB/SEC)
REFERRED RPM	=	13768.30	
REFERRED HORSE POWER	=	52.80	(HP)
REFERRED MOMENT	=	19.84	(FT-LB)
REFERRED FLOW RATE	=	2.06	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.6705	
TOTAL/TOTAL EFFICIENCY	=	.8257	
TOTAL/STATIC PRESSURE RATIO	=	2.3232	
TOTAL/TOTAL PRESSURE RATIO	=	1.9404	
HEAD COEFFICIENT	=	9.2009	
BLADE/JET SPEED RATIO	=	.3297	
THEORETICAL DEGREE OF REACTION	=	.3691	
MACH NUMBER AT STATION 0	=	.2057	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	2.400	35.280	615.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1017	.9133	.0867	.0867	0.0000
2	3.003	.940	0.0000	.2347	1.0470	.9104	.0896	.0896	.2520
3	3.195	1.000	.0270	.2526	1.0000	.9080	.0920	.0920	.4713
4	3.432	1.074	0.0000	.2745	.9401	.9061	.0939	.0939	.7556
5	3.627	1.135	0.0000	.2926	.8985	.9045	.0955	.0955	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	429.69	-17.24	949.28	1042.07	429.69	-17.24	466.79	634.69	482.41
2	408.34	3.88	892.02	981.05	408.34	3.88	367.88	549.63	524.14
3	390.02	8.92	844.44	930.20	390.02	8.92	286.72	484.16	557.72
4	366.68	31.85	787.54	869.30	366.68	31.85	188.60	413.57	598.94
5	347.33	41.21	741.05	819.45	347.33	41.21	108.02	366.07	633.03

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.93	.57	65.65	47.37	615.30	524.[illegible]	32.303	17.101	1.0594	1.[illegible]
2	.87	.48	65.41	42.02	615.30	535.21	33.474	20.559	1.0543	1.7160
3	.81	.42	65.21	36.32	615.30	543.30	33.649	21.767	1.0485	1.[illegible]
4	.75	.36	65.04	27.22	615.30	552.42	33.845	23.207	1.0424	1.5[illegible]
5	.71	.32	64.89	17.28	615.30	559.42	33.996	24.362	1.0378	1.448[illegible]

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	2.400	35.280	615.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9855	.8888	.1112	.1112	0.0000
2	3.020	.925	-.0168	.2218	.9479	.8929	.1071	.1071	.2279
3	3.265	1.000	-.0405	.2447	1.0000	.8960	.1040	.1040	.4256
4	3.585	1.098	-.1537	.2747	1.1024	.9031	.0970	.0970	.7221
5	3.837	1.175	-.2100	.2983	1.2069	.9086	.0914	.0914	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	371.69	-14.91	-424.45	564.39	371.69	-14.91	-894.47	968.74	470.02
2	357.52	3.40	-294.20	463.02	357.52	3.40	-821.28	895.73	527.07
3	377.17	8.63	-267.65	462.57	377.17	8.63	-837.50	918.55	569.85
4	415.78	36.11	-243.64	483.26	415.78	36.11	-869.41	964.39	625.77
5	455.20	54.01	-239.71	517.29	455.20	54.01	-909.39	1018.39	669.68

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.53	.90	-48.80	-67.44	505.89	429.39	15.616	12.935	2.2552	2.2274
2	.43	.82	-39.45	-66.48	511.68	493.84	16.589	14.651	2.1268	2.4081
3	.42	.84	-35.36	-65.76	511.54	493.73	16.632	14.692	2.1212	2.4013
4	.44	.89	-30.37	-64.45	511.43	491.99	16.693	14.576	2.1135	2.4204
5	.48	.94	-27.77	-63.41	510.51	488.25	16.610	14.209	2.1241	2.4829

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	557.48	23.576	1.8
2	560.61	24.180	1.7
3	563.94	24.802	1.7
4	569.39	25.799	1.8
5	574.55	26.746	1.9

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	2.400	35.280	615.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.7374	2.2592	.7134	.8560	7.9191	.3554	.3548
2	2.4080	2.1268	.7584	.8683	5.9763	.4091	.3561
3	2.4013	2.1212	.7616	.8723	5.2634	.4359	.4179
4	2.4204	2.1135	.7564	.8770	4.6802	.4662	.4946
5	2.4829	2.1241	.7443	.8795	4.2221	.4867	.5612

MASS AVERAGED QUANTITIES

HORSE POWER = 161.10 (HP)
MOMENT = 42.31 (FT-LB)
FLOW RATE = 4.54 (LB/SEC)

REFERRED RPM = 18357.73
REFERRED HORSE POWER = 61.61 (HP)
REFERRED MOMENT = 17.63 (FT-LB)
REFERRED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7513
TOTAL/TOTAL EFFICIENCY= .8713
TOTAL/STATIC PRESSURE RATIO = 2.4587
TOTAL/TOTAL PRESSURE RATIO = 2.1383

HEAD COEFFICIENT = 5.4774
BLADE/JET SPEED RATIO = .4273
THEORETICAL DEGREE OF REACTION= .4317
MACH NUMBER AT STATION 0 = .2055

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	30000.0	2.400	35.280	615.30

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1040	.9194	.0806	.0806	0.0000
2	3.003	.940	0.0000	.2347	1.0479	.9149	.0851	.0851	.2538
3	3.195	1.000	.0290	.2526	1.0000	.9113	.0887	.0887	.4734
4	3.432	1.074	0.0000	.2745	.9395	.9090	.0910	.0910	.7571
5	3.627	1.135	0.0000	.2926	.8895	.9071	.0929	.0929	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	416.68	-16.71	920.47	1010.53	416.68	-16.71	196.86	461.15	723.62
2	395.49	3.76	863.95	950.17	395.49	3.76	77.74	403.02	786.21
3	377.42	8.64	817.15	900.14	377.42	8.64	-19.43	378.02	836.58
4	354.58	30.80	761.55	840.62	354.58	30.80	-136.86	381.32	898.41
5	335.72	39.83	716.29	792.06	335.72	39.83	-233.26	410.74	949.55

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.90	.41	65.65	25.29	615.30	530.33	33.575	19.958	1.0508	1.7677
2	.83	.35	65.41	11.12	615.30	540.17	33.708	21.370	1.0466	1.6509
3	.78	.33	65.21	-2.95	615.30	547.08	33.822	22.532	1.0431	1.5658
4	.73	.33	65.04	-21.11	615.30	556.50	33.991	23.916	1.0379	1.4752
5	.68	.35	64.89	-34.79	615.30	563.10	34.122	25.019	1.0339	1.4101

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	30000.0	2.400	35.280	615.30

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	1.0001	.9163	.0837	.0837	0.0000
2	3.020	.925	-.0168	.2218	.8969	.8989	.1012	.1012	.2180
3	3.265	1.000	-.0405	.2447	1.0000	.8858	.1142	.1142	.4086
4	3.585	1.098	-.1537	.2747	1.1731	.8982	.1018	.1018	.7074
5	3.837	1.175	-.2100	.2983	1.3365	.9080	.0920	.0920	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	351.32	-14.09	-140.43	378.60	351.32	-14.09	-845.45	915.65	705.03
2	315.07	2.99	66.87	322.10	315.07	2.99	-723.75	789.36	770.61
3	351.28	8.04	74.77	359.24	351.28	8.04	-780.01	855.50	854.78
4	412.09	35.79	76.97	420.74	412.09	35.79	-861.69	955.82	938.65
5	469.47	55.70	66.63	477.43	469.47	55.70	-937.90	1050.31	1004.53

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.35	.86	-21.79	-67.44	487.97	476.05	14.227	13.047	2.4798	2.7041
2	.29	.72	11.98	-66.48	511.06	502.42	16.897	15.919	2.0879	2.2162
3	.33	.78	12.02	-65.76	512.17	501.43	16.840	15.636	2.0950	2.2563
4	.38	.87	10.58	-64.45	513.46	498.73	16.976	15.332	2.0782	2.3011
5	.44	.96	8.08	-63.41	513.25	494.28	16.923	14.834	2.0847	2.3784

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	545.81	22.073	1.7
2	554.27	23.386	1.5
3	562.33	24.681	1.6
4	574.75	26.776	1.7
5	586.07	28.778	1.9

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.400	35.280	615.30

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.7041	2.4798	.8365	.9055	3.4936	.5350	.3928
2	2.2162	2.0879	.8331	.8932	2.4328	.6411	.3438
3	2.2563	2.0950	.8080	.8800	2.1916	.6755	.4203
4	2.3011	2.0782	.7812	.8776	1.9410	.7178	.5038
5	2.3784	2.0847	.7564	.8761	1.7983	.7457	.5735

MASS AVERAGED QUANTITIES

HORSE POWER = 161.77 (HP)
MOMENT = 28.32 (FT-LB)
FLOW RATE = 4.52 (LB/SEC)

REFERRED RPM = 27536.60
REFERRED HORSE POWER = 61.97 (HP)
REFERRED MOMENT = 11.80 (FT-LB)
REFERRED FLOW RATE = 2.05 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .8047
TOTAL/TOTAL EFFICIENCY= .8854
TOTAL/STATIC PRESSURE RATIO = 2.3287
TOTAL/TOTAL PRESSURE RATIO = 2.1358

HEAD COEFFICIENT = 2.3029
BLADE/JET SPEED RATIO = .6590
THEORETICAL DEGREE OF REACTION= .4378
MACH NUMBER AT STATION 0 = .2045

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	2.600	38.220	626.18

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1017	.9134	.0866	.0866	0.0000
2	3.003	.940	0.0000	.2347	1.0469	.9105	.0895	.0895	.2518
3	3.195	1.000	.0290	.2526	1.0000	.9082	.0918	.0918	.4710
4	3.432	1.074	0.0000	.2745	.9401	.9062	.0938	.0938	.7554
5	3.627	1.135	0.0000	.2926	.8905	.9046	.0954	.0954	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	436.14	-17.50	963.46	1057.73	436.14	-17.50	481.05	649.57	482.41
2	414.48	3.94	905.45	995.81	414.48	3.94	381.31	563.21	524.14
3	395.90	9.06	857.16	944.21	395.90	9.06	299.44	496.47	557.72
4	372.19	32.33	799.38	882.37	372.19	32.33	200.44	423.97	598.94
5	352.54	41.83	752.17	831.74	352.54	41.83	119.14	374.47	633.03

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.93	.57	65.65	47.81	626.18	533.08	36.051	20.524	1.0602	1.6622
2	.87	.49	65.41	42.62	626.18	543.66	36.261	22.113	1.0540	1.7264
3	.82	.43	65.21	37.10	626.18	551.99	36.433	23.432	1.0491	1.6311
4	.76	.37	65.04	28.31	626.18	561.39	36.646	25.005	1.0429	1.5285
5	.71	.32	64.89	18.67	626.18	568.61	36.811	26.266	1.0383	1.4551

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	2.600	38.220	626.18

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0718	.1912	.9841	.8925	.1076	.1076	0.0000
2	3.028	.925	-.0168	.2218	.9534	.8962	.1039	.1039	.2284
3	3.265	1.000	-.0405	.2447	1.0000	.8790	.1011	.1011	.4268
4	3.585	1.098	-.1537	.2747	1.0944	.9058	.0943	.0943	.7231
5	3.837	1.175	-.2100	.2983	1.1922	.9111	.0889	.0889	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	399.16	-16.01	-490.56	632.64	399.16	-16.01	-960.58	1040.34	470.02
2	386.72	3.67	-361.27	529.23	386.72	3.67	-888.74	968.88	522.07
3	405.61	9.28	-330.81	523.49	405.61	9.28	-900.66	987.82	569.85
4	443.92	38.56	-302.49	538.56	443.92	38.56	-978.26	1029.67	625.77
5	483.56	57.37	-296.36	570.04	483.56	57.37	-966.04	1081.83	669.68

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.59	.97	-50.87	-67.44	510.46	477.15	16.268	12.846	2.3494	[illegible]
2	.49	.89	-43.05	-66.48	515.51	492.20	17.203	14.631	2.2217	[illegible]
3	.48	.91	-39.20	-65.76	515.25	492.44	17.245	14.718	2.2163	[illegible]
4	.50	.95	-34.27	-64.45	515.80	490.86	17.306	14.630	2.2085	[illegible]
5	.53	1.00	-31.51	-63.41	513.91	486.87	17.205	14.240	2.2214	2.6840

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI)	EQUIV/STATIC PRESSURE RATIO
1	547.21	25.502	2.0
2	570.32	26.146	1.8
3	573.64	26.810	1.8
4	579.08	27.873	1.9
5	584.26	28.883	2.0

SET NUMBER	PAGE NUMBER	RP	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	2.600	38.720	626.18

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	2.9751	2.3494	.6985	.8535	8.6546	.3399	.3919
2	2.6122	2.2217	.7367	.8667	6.5718	.3901	.3968
3	2.5968	2.2163	.7424	.8711	5.7731	.4162	.4533
4	2.6125	2.2085	.7400	.8765	5.0333	.4457	.5242
5	2.6840	2.2214	.7295	.8793	4.6155	.4655	.5865

MASS AVERAGED QUANTITIES

HORSE POWER =	185.30	(HP)
MOMENT =	48.66	(FT-LB)
FLOW RATE =	4.89	(LB/SEC)
REFERRED RPM =	18197.55	
REFERRED HORSE POWER =	64.84	(HP)
REFERRED MOMENT =	18.72	(FT-LB)
REFERRED FLOW RATE =	2.07	(LB/SEC)
TOTAL/STATIC EFFICIENCY =	.7323	
TOTAL/TOTAL EFFICIENCY=	.8702	
TOTAL/STATIC PRESSURE RATIO =	2.6620	
TOTAL/TOTAL PRESSURE RATIO =	2.2330	
HEAD COEFFICIENT =	6.0033	
BLADE/JET SPEED RATIO =	.4001	
THEORETICAL DEGREE OF REACTION=	.4659	
MACH NUMBER AT STATION 0 =	.2061	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	38000.0	2.600	38.220	626.18

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1042	.9205	.0795	.0795	0.0000
2	3.003	.940	0.0000	.2347	1.0480	.9159	.0841	.0841	.2532
3	3.195	1.000	.0290	.2526	1.0000	.9123	.0877	.0877	.4727
4	3.432	1.074	0.0000	.2745	.9393	.9098	.0902	.0902	.7566
5	3.627	1.135	0.0000	.2926	.8892	.9077	.0923	.0923	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	427.64	-17.15	944.68	1037.11	427.64	-17.15	221.06	481.71	723.62
2	405.86	3.86	886.61	975.10	405.86	3.86	100.40	418.12	786.21
3	387.29	8.86	838.53	923.69	387.29	8.86	1.94	387.40	836.58
4	363.80	31.60	781.35	862.47	363.80	31.60	-117.06	383.47	898.41
5	344.40	40.86	734.79	812.52	344.40	40.86	-214.76	407.92	949.55

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.91	.42	65.65	27.34	626.18	536.68	36.326	21.173	1.0521	1.8052
2	.85	.36	65.41	13.90	626.18	547.06	36.474	22.733	1.0479	1.6813
3	.80	.34	65.21	.29	626.18	555.18	36.601	24.020	1.0442	1.5912
4	.74	.33	65.04	-17.84	626.18	564.28	36.784	25.554	1.0390	1.4957
5	.69	.35	64.89	-31.95	626.18	571.24	36.927	26.778	1.0350	1.4273

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	30000.0	2.600	38.220	626.18

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	-.0710	.1912	.9966	.9210	.0790	.0790	0.0000
2	3.020	.925	-.0168	.2218	.9100	.9055	.0946	.0946	.2200
3	3.265	1.000	-.0405	.2447	1.0000	.8938	.1063	.1063	.4133
4	3.585	1.098	-.1537	.2747	1.1540	.9052	.0949	.0949	.7111
5	3.837	1.175	-.2100	.2983	1.3010	.9141	.0859	.0859	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	391.31	-15.70	-236.68	457.59	391.31	-15.70	-941.70	1019.89	705.03
2	357.29	3.39	-30.13	358.57	357.29	3.39	-820.74	895.14	790.61
3	392.64	8.98	-17.07	393.11	392.64	8.98	-871.85	956.23	854.79
4	453.10	39.35	-8.80	454.89	453.10	39.35	-947.45	1050.96	938.65
5	510.82	60.61	-15.98	514.65	510.82	60.61	-1020.51	1142.82	1004.53

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.43	.96	-31.17	-67.44	484.65	462.22	14.009	12.324	2.7282	3.101[illegible]
2	.33	.82	-4.82	-66.48	506.21	495.51	16.488	15.300	2.3181	2.4780
3	.36	.88	-2.49	-65.76	507.01	494.15	16.387	14.978	2.3423	2.5517
4	.42	.97	-1.11	-64.45	507.98	490.76	16.502	14.626	2.3160	2.6131
5	.48	1.06	-1.79	-63.41	507.39	485.35	16.416	14.053	2.3282	2.7196

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	553.78	23.629	1.9
2	562.19	25.010	1.6
3	570.23	26.377	1.8
4	582.67	28.589	2.0
5	594.83	30.706	2.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.600	38.220	626.18

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.1012	2.7282	.8181	.9067	3.9706	.5018	.4379
2	2.4980	2.3181	.8325	.8973	2.8019	.5974	.4006
3	2.5517	2.3323	.8105	.8856	2.5248	.6293	.4707
4	2.6131	2.3160	.7865	.8848	2.2375	.6685	.5473
5	2.7198	2.3282	.7630	.8844	2.0751	.6942	.6112

MASS AVERAGED QUANTITIES

HORSE POWER = 201.29 (HP)
MOMENT = 35.24 (FT-LB)
FLOW RATE = 4.88 (LB/SEC)

REFERRED RPM = 27296.32
REFERRED HORSE POWER = 70.44 (HP)
REFERRED MOMENT = 13.55 (FT-LB)
REFERRED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .8050
TOTAL/TOTAL EFFICIENCY= .8708
TOTAL/STATIC PRESSURE RATIO = 2.6433
TOTAL/TOTAL PRESSURE RATIO = 2.3736

HEAD COEFFICIENT = 2.6467
BLADE/JET SPEED RATIO = .6147
THEORETICAL DEGREE OF REACTION= .4858
MACH NUMBER AT STATION 0 = .2058

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	15000.0	2.800	41.160	636.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA./VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1050	.9160	.0840	.0840	0.0000
2	3.003	.940	0.0000	.2347	1.0481	.9091	.0909	.0909	.2504
3	3.195	1.000	.0290	.2526	1.0000	.9036	.0964	.0964	.4688
4	3.432	1.074	0.0000	.2745	.9401	.9019	.0981	.0981	.7536
5	3.627	1.135	0.0000	.2926	.8910	.9005	.0995	.0995	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	464.88	-18.65	1026.95	1127.43	464.88	-18.65	665.14	811.71	361.81
2	440.92	4.19	963.20	1059.33	440.92	4.19	570.09	720.72	393.10
3	420.70	9.63	910.85	1003.36	420.70	9.63	492.56	647.84	418.29
4	395.51	34.35	849.46	937.65	395.51	34.35	400.25	563.75	449.20
5	374.84	44.47	799.73	884.34	374.84	44.47	324.96	498.07	474.77

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	1.00	.72	65.65	55.05	636.67	530.90	38.586	20.430	1.0667	2.0146
2	.93	.63	65.41	52.28	636.67	543.29	38.737	22.235	1.0626	1.8511
3	.87	.56	65.21	49.50	636.67	552.90	38.878	23.728	1.0587	1.7347
4	.81	.48	65.04	45.34	636.67	563.51	39.161	25.546	1.0510	1.6112
5	.75	.42	64.89	40.93	636.67	571.59	39.376	26.999	1.0453	1.5245

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	15000.0	2.800	41.160	636.67

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9788	.8773	.1227	.1227	0.0000
2	3.020	.925	-.0168	.2218	.9761	.8768	.1233	.1233	.2333
3	3.265	1.000	-.0405	.2447	1.0000	.8764	.1237	.1237	.4333
4	3.585	1.098	-.1537	.2747	1.0619	.8807	.1194	.1194	.7281
5	3.837	1.175	-.2100	.2983	1.1319	.8841	.1160	.1160	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	430.45	-17.27	-683.39	807.84	430.45	-17.27	-1035.90	1121.91	352.51
2	429.27	4.08	-590.78	730.28	429.27	4.08	-986.08	1075.48	395.31
3	439.79	10.06	-549.15	703.62	439.79	10.06	-976.54	1071.05	427.39
4	467.02	40.56	-507.24	690.69	467.02	40.56	-976.57	1083.25	469.33
5	497.79	59.06	-492.21	702.53	497.79	59.06	-994.47	1113.66	502.26

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.75	1.04	-57.80	-67.44	534.74	480.44	18.800	12.923	2.1894	3.1849
2	.67	.99	-54.00	-66.48	534.79	490.41	19.078	14.088	2.1575	2.9216
3	.65	.98	-51.31	-65.76	534.20	493.01	19.092	14.417	2.1559	2.8550
4	.63	.99	-47.37	-64.45	533.55	493.85	19.186	14.637	2.1454	2.8120
5	.65	1.03	-44.68	-63.41	532.34	491.27	19.086	14.410	2.1565	2.8563

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	585.17	28.723	2.2
2	586.66	29.092	2.1
3	588.46	29.513	2.0
4	591.50	30.268	2.1
5	594.47	30.974	2.1

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	15000.0	2.800	41.160	636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.1849	2.1894	.5682	.7981	16.4689	.2464	.3563
2	2.9216	2.1575	.6065	.8113	13.0634	.2767	.3885
3	2.8550	2.1559	.6215	.8167	11.3249	.2972	.4377
4	2.8120	2.1454	.6333	.8262	9.6977	.3211	.5018
5	2.8563	2.1565	.6325	.8313	8.7936	.3372	.5619

AVERAGED QUANTITIES

[illegible]OWER	=	182.97	(HP)
M[illegible]NT	=	64.06	(FT-LB)
FLOW RATE	=	5.25	(LB/SEC)
REFERRED RPM	=	13535.26	
REFERRED HORSE POWER	=	58.96	(HP)
REFERRED MOMENT	=	22.88	(FT-LB)
REFERRED FLOW RATE	=	2.08	(LB/SEC)
TOTAL/STATIC EFFICIENCY	=	.6154	
TOTAL/TOTAL EFFICIENCY	=	.8174	
TOTAL/STATIC PRESSURE RATIO	=	2.9023	
TOTAL/TOTAL PRESSURE RATIO	=	2.1579	
HEAD COEFFICIENT	=	11.6793	
BLADE/JET SPEED RATIO	=	.2926	
THEORETICAL DEGREE OF REACTION	=	.4468	
MACH NUMBER AT STATION 0	=	.2072	

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	20000.0	2.800	41.160	636.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1018	.9146	.0854	.0854	0.0000
2	3.003	.940	0.0000	.2347	1.0470	.9117	.0883	.0883	.2509
3	3.195	1.000	.0290	.2526	1.0000	.9094	.0906	.0906	.4698
4	3.432	1.074	0.0000	.2745	.9400	.9071	.0929	.0929	.7546
5	3.627	1.135	0.0000	.2926	.8902	.9052	.0948	.0948	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	450.26	-18.06	994.65	1091.97	450.26	-18.06	512.24	682.24	482.41
2	427.89	4.06	934.73	1028.02	427.89	4.06	410.59	593.04	524.14
3	408.68	9.35	884.83	974.69	408.68	9.35	327.11	523.55	557.72
4	384.14	33.36	825.04	910.70	384.14	33.36	226.10	446.99	598.94
5	363.79	43.16	776.17	858.29	363.79	43.16	143.14	393.32	633.03

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.96	.60	65.65	48.69	636.67	537.45	38.729	21.405	1.0628	1.9229
2	.90	.52	65.41	43.82	636.67	548.73	38.967	23.161	1.0563	1.7771
3	.84	.45	65.21	38.68	636.67	557.62	39.161	24.622	1.0510	1.6717
4	.78	.38	65.04	30.48	636.67	567.66	39.394	26.365	1.0448	1.5611
5	.73	.33	64.89	21.48	636.67	575.37	39.575	27.768	1.0400	1.4823

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	20000.0	2.800	41.160	636.67

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9833	.8933	.1067	.1067	0.0000
2	3.020	.925	-.0168	.2218	.9561	.8963	.1037	.1037	.2288
3	3.265	1.000	-.0405	.2447	1.0000	.8985	.1015	.1015	.4274
4	3.585	1.098	-.1537	.2747	1.0908	.9038	.0962	.0962	.7235
5	3.837	1.175	-.2100	.2983	1.1853	.9080	.0920	.0920	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	413.86	-16.60	-525.94	669.45	413.86	-16.60	-995.95	1078.65	470.02
2	402.41	3.82	-397.32	565.52	402.41	3.82	-924.39	1008.19	527.07
3	420.89	9.63	-364.72	557.01	420.89	9.63	-934.57	1025.02	569.85
4	459.09	39.87	-334.21	569.26	459.09	39.87	-959.98	1064.86	625.77
5	498.88	59.19	-326.97	599.41	498.88	59.19	-996.65	1116.11	669.68

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.62	1.01	-51.80	-67.44	515.68	[illegible].38	17.000	13.072	2.4211	3.1486
2	.52	.93	-44.64	-66.48	520.28	493.67	17.922	14.914	2.2966	2.7599
3	.51	.94	-40.91	-65.76	519.95	494.14	17.961	15.029	2.2916	2.7388
4	.52	.98	-36.06	-64.45	519.63	492.66	18.003	14.940	2.2863	2.7551
5	.55	1.03	-33.24	-63.41	518.46	488.56	17.872	14.517	2.3031	2.8352

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	575.20	27.146	2.1
2	578.25	27.823	1.9
3	581.56	28.526	1.9
4	587.82	29.649	2.0
5	592.22	30.719	2.1

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	20000.0	2.800	41.160	636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.1486	2.4211	.6802	.8513	9.1863	.3299	.3902
2	2.7599	2.2966	.7261	.8646	7.0119	.3776	.3982
3	2.7308	2.2916	.7329	.8691	6.1525	.4032	.4541
4	2.7551	2.2863	.7313	.8732	5.3619	.4319	.5247
5	2.8352	2.3031	.7211	.8755	4.9165	.4510	.5869

MASS AVERAGED QUANTITIES

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          HORSE POWER =   208.91   (HP)
          MOMENT      =    54.86   (FT-LB)
          FLOW RATE   =     5.24   (LB/SEC)

   REFERRED  RPM         =  18047.91
   REFERRED HORSE POWER  =     67.38   (HP)
   REFERRED MOMENT       =     19.59   (FT-LB)
   REFERRED FLOW RATE    =      2.07   (LB/SEC)

     TOTAL/STATIC EFFICIENCY =   .7227
      TOTAL/TOTAL  EFFICIENCY=   .8677
 TOTAL/STATIC PRESSURE RATIO =  2.8114
 TOTAL/TOTAL  PRESSURE RATIO =  2.3092

HEAD COEFFICIENT             =  6.3944
BLADE/JET SPEED RATIO        =   .3955
THEORETICAL DEGREE OF REACTION=  .4664
MACH NUMBER AT STATION 0     =   .2069
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SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	25000.0	2.800	41.160	636.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1033	.9178	.0822	.0822	0.0000
2	3.003	.940	0.0000	.2347	1.0476	.9139	.0861	.0861	.2527
3	3.195	1.000	.0290	.2526	1.0000	.9108	.0892	.0892	.4721
4	3.432	1.074	0.0000	.2745	.9396	.9085	.0915	.0915	.7562
5	3.627	1.135	0.0000	.2926	.8897	.9065	.0935	.0935	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	434.12	-17.41	958.99	1052.81	434.12	-17.41	355.97	561.67	603.01
2	412.21	3.92	900.48	990.35	412.21	3.92	245.31	479.70	655.17
3	393.49	9.00	851.94	938.46	393.49	9.00	154.79	422.93	697.15
4	369.73	32.11	794.09	876.54	369.73	32.11	45.42	373.89	748.67
5	350.09	41.54	746.93	825.95	350.09	41.54	-44.36	355.32	791.29

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.92	.49	65.65	39.35	636.67	544.44	39.017	22.561	1.0549	1.8244
2	.86	.42	65.41	30.76	636.67	555.06	39.199	24.253	1.0500	1.6971
3	.81	.36	65.21	21.47	636.67	563.38	39.353	25.651	1.0459	1.6045
4	.75	.32	65.04	7.80	636.67	572.74	39.562	27.316	1.0404	1.5068
5	.70	.30	64.89	-7.22	636.67	579.90	39.724	28.648	1.0361	1.4357

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	25000.0	2.800	41.160	636.67

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.7888	.9114	.0886	.0886	0.0000
2	3.020	.925	-.0168	.2218	.9357	.9126	.0875	.0875	.2250
3	3.265	1.000	-.0405	.2447	1.0000	.9134	.0866	.0866	.4237
4	3.585	1.098	-.1537	.2747	1.1196	.9075	.0926	.0926	.7210
5	3.837	1.175	-.2100	.2983	1.2386	.9028	.0972	.0972	1.0000

	ABSOLUTE VELOCITY (FPS)				RELATIVE VELOCITY (FPS)				
STREAM LINE	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	411.06	-16.49	-401.70	574.98	411.06	-16.49	-989.22	1071.35	587.52
2	388.97	3.70	-234.66	454.28	388.97	3.70	-893.50	974.50	658.84
3	415.71	9.51	-210.75	466.18	415.71	9.51	-923.07	1012.40	712.31
4	465.42	40.42	-198.99	504.70	465.42	40.42	-973.20	1079.52	782.21
5	514.87	61.09	-191.50	552.72	514.87	61.09	-1028.61	1151.90	837.11

	MACH NUMBER		FLOW ANGLE (DEG)		TEMPERATURE (DEG. R)		PRESSURE (PSI)		PRESSURE RATIO	
STREAM LINE	ABSOLUTE	RELATIVE	ABSOLUTE	RELATIVE	TOTAL	STATIC	TOTAL	STATIC	TOT/TOT	TOT/STA
1	.54	1.00	-44.34	-67.44	501.15	473.64	15.752	12.928	2.6130	3.1838
2	.42	.89	-31.10	-66.48	512.76	495.58	17.412	15.455	2.3639	2.6632
3	.43	.93	-26.89	-65.76	512.84	494.76	17.425	15.367	2.3622	2.6784
4	.46	.99	-22.31	-64.45	512.87	491.67	17.286	14.912	2.3811	2.7601
5	.51	1.07	-20.40	-63.41	511.63	486.21	16.946	14.178	2.4289	2.9032

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	569.15	26.354	2.0
2	574.60	27.376	1.8
3	580.05	28.405	1.8
4	588.64	30.065	2.0
5	596.62	31.644	2.2

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	25000.0	2.800	41.160	636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.1838	2.6130	.7556	.8870	5.9273	.4107	.4397
2	2.6632	2.3639	.7973	.8931	4.3511	.4794	.4254
3	2.6784	2.3622	.7928	.8932	3.8622	.5088	.4848
4	2.7601	2.3811	.7723	.8858	3.4370	.5394	.5610
5	2.9832	2.4289	.7482	.8770	3.2078	.5583	.6253

MASS AVERAGED QUANTITIES

HORSE POWER = 221.79 (HP)
MOMENT = 46.59 (FT-LB)
FLOW RATE = 5.21 (LB/SEC)

REFERRED RPM = 22558.76
REFERRED HORSE POWER = 71.48 (HP)
REFERRED MOMENT = 16.64 (FT-LB)
REFERRED FLOW RATE = 2.06 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .7786
TOTAL/TOTAL EFFICIENCY= .8885
TOTAL/STATIC PRESSURE RATIO = 2.7063
TOTAL/TOTAL PRESSURE RATIO = 2.4070

HEAD COEFFICIENT = 4.0544
BLADE/JET SPEED RATIO = .4966
THEORETICAL DEGREE OF REACTION= .5009
MACH NUMBER AT STATION 0 = .2058

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE	INLET TOTAL TEMPERATURE
1	1	30000.0	2.800	41.160	636.67

STATOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION (IN)	X=R/RM	RADIAL SHIFT (IN)	BLADE OPENING (IN)	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZETA* CONTINUITY	FLOW RATE FRACTION
1	2.764	.865	0.0000	.2126	1.1042	.9209	.0791	.0791	0.0000
2	3.003	.940	0.0000	.2347	1.0480	.9164	.0836	.0836	.2529
3	3.195	1.000	.0290	.2526	1.0000	.9127	.0873	.0873	.4724
4	3.432	1.074	0.0000	.2745	.9393	.9101	.0899	.0899	.7563
5	3.627	1.135	0.0000	.2926	.8891	.9079	.0921	.0921	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	434.48	-17.43	959.78	1053.69	434.48	-17.43	236.17	494.82	723.62
2	412.35	3.92	900.77	990.68	412.35	3.92	114.57	427.98	786.21
3	393.47	9.00	851.90	938.42	393.47	9.00	15.31	393.87	836.58
4	369.58	32.10	793.76	876.12	369.58	32.10	-104.65	385.45	898.41
5	349.84	41.51	746.41	825.37	349.84	41.51	-203.14	406.67	949.55

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.92	.43	65.65	28.53	636.67	544.28	39.097	22.585	1.0528	1.8[illegible]
2	.86	.37	65.41	15.53	636.67	555.00	39.257	24.280	1.0485	1.69[illegible]
3	.81	.34	65.21	2.23	636.67	563.39	39.396	25.680	1.0449	[illegible]
4	.75	.33	65.04	-15.81	636.67	572.79	39.594	27.348	1.0395	1.50[illegible]
5	.70	.34	64.89	-30.14	636.67	579.98	39.749	28.689	1.0355	1.435[illegible]

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	2	30000.0	2.800	41.160	636.67

ROTOR EXIT SOLUTION

STREAM LINE	RADIAL POSITION	X=R/RM	RADIAL SHIFT	BLADE OPENING	Y=VA /VAM	BLADE EFFICIENCY	LOSS COEFFICIENT	ZE10* CONTINUITY	FLOW RATE FRACTION
1	2.693	.825	.0710	.1912	.9952	.9230	.0770	.0770	0.0000
2	3.020	.925	-.0168	.2218	.9151	.9084	.0916	.0916	.2210
3	3.265	1.000	-.0405	.2447	1.0000	.8975	.1025	.1025	.4152
4	3.585	1.098	-.1537	.2747	1.1467	.9052	.0949	.0949	.7126
5	3.837	1.175	-.2100	.2983	1.2872	.9112	.0888	.0888	1.0000

STREAM LINE	ABSOLUTE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	RELATIVE VELOCITY (FPS) AXIAL COMPONENT	RADIAL COMPONENT	TANGENTIAL COMPONENT	OVERALL VELOCITY	WHEEL VELOCITY
1	409.70	-16.43	-280.93	497.03	409.70	-16.43	-985.95	1067.81	705.03
2	376.73	3.58	-74.78	384.09	376.73	3.58	-865.39	943.84	790.61
3	411.68	9.42	-59.36	416.05	411.60	9.42	-914.14	1002.61	854.78
4	472.07	41.00	-48.47	476.32	472.07	41.00	-987.13	1094.97	938.65
5	529.93	62.87	-54.16	536.39	529.93	62.87	-1058.69	1185.58	1004.53

STREAM LINE	MACH NUMBER ABSOLUTE	RELATIVE	FLOW ANGLE (DEG) ABSOLUTE	RELATIVE	TEMPERATURE (DEG. R) TOTAL	STATIC	PRESSURE (PSI) TOTAL	STATIC	PRESSURE RATIO TOT/TOT	TOT/STA
1	.47	1.01	-34.44	-67.44	488.13	467.57	14.532	12.501	2.8323	3.2926
2	.35	.86	-11.23	-66.48	508.97	496.69	17.006	15.613	2.4204	2.6363
3	.38	.92	-8.21	-65.76	509.62	495.22	16.885	15.272	2.4377	2.6950
4	.44	1.01	-5.86	-64.45	510.42	491.54	16.943	14.849	2.4293	2.7719
5	.50	1.10	-5.84	-63.41	509.66	485.72	16.788	14.186	2.4517	2.9014

STREAM LINE	EQUIVALENT TEMPERATURE (DEG. R)	EQUIVALENT INLET PRESSURE (PSI	EQUIV/STATIC PRESSURE RATIO
1	562.45	25.336	2.0
2	570.82	26.790	1.7
3	570.86	28.233	1.8
4	591.31	30.569	2.1
5	602.68	32.885	2.3

SET NUMBER	PAGE NUMBER	RPM	TOTAL/STATIC PRESSURE RATIO	INLET TOTAL PRESSURE (PSI)	INLET TOTAL TEMPERATURE (DEG. R)
1	3	30000.0	2.800	41.160	636.67

OVERALL TURBINE CHARACTERISTICS

STREAM LINE	PRESSURE RATIO TOT/STA	PRESSURE RATIO TOT/TOT	EFFICIENCY TOT/STA	EFFICIENCY TOT/TOT	HEAD COEFFICIENT	BLADE/JET SPEED RATIO	THEORETICAL DEGREE OF REACTION
1	3.2926	2.8323	.8085	.9068	4.2165	.4820	.4539
2	2.6363	2.4204	.8291	.8987	2.9944	.5779	.4213
3	2.6950	2.4377	.8090	.8879	2.6966	.6090	.4808
4	2.7719	2.4293	.7847	.8853	2.3954	.6461	.5637
5	2.9014	2.4517	.7603	.8826	2.2265	.6702	.6262

MASS AVERAGED QUANTITIES

HORSE POWER = 229.28 (HP)
MOMENT = 40.14 (FT-LB)
FLOW RATE = 5.22 (LB/SEC)

REFERRED RPM = 27070.52
REFERRED HORSE POWER = 73.89 (HP)
REFERRED MOMENT = 14.34 (FT-LB)
REFERRED FLOW RATE = 2.07 (LB/SEC)

TOTAL/STATIC EFFICIENCY = .8018
TOTAL/TOTAL EFFICIENCY= .8917
TOTAL/STATIC PRESSURE RATIO = 2.8001
TOTAL/TOTAL PRESSURE RATIO = 2.4824

HEAD COEFFICIENT = 2.8270
BLADE/JET SPEED RATIO = .5948
THEORETICAL DEGREE OF REACTION= .5035
MACH NUMBER AT STATION 0 = .2062

APPENDIX: G

COMPUTER LISTING

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&MAIN  T=00004 IS ON CR00025 USING 00147 BLKS R=0000

FTN4,L
      BLOCK DATA
      COMMON/ABA/BA17,BLEX
      COMMON/CUR/COSL(10)
      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
      COMMON/TRS/TRAS
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/COZ/ICOR,ICOZ,IINC,IAI,ICL,IAN,ICON
      COMMON/MAC/IN
      COMMON/IWI/IND,INZ,IWR
      COMMON/AUS/XCL
      COMMON/CSS/CJ,G,Q1
      COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
     *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
     *ASF,AMS,B1(20)
      COMMON/VAR2/B6(20),ZR,ZS,ARF,B2(20),PR,AMR,VU1(10)
      COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
      COMMON/VAR4/BR1,RR2,RR3,RR1,RR3,RR5,VA2(10)
      COMMON/VAR5/PRA11(10),RINCI(10),ALFA11(10),BETA11(10),ZETA1(10),
     *V2(10),ALFA22(10),BETA22(10)
      COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
     *WR2(10),T2S(10),T2TS(10)
      COMMON/VAR7/TTIS(5),BETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
     *RSTAR(10),AKIS(10),PSIR(10)
      COMMON/VAR8/DR1(10),AMW1(10),AMV2(10),BETET(10),PRAT1T(10),AMR2(
     *10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),X2(10)
      COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
     *S1(10),DSDX1(10),W11(10),HE(10)
      COMMON/VAR10/WU1(10),DHEDX(10),DSDX2(10),RI1(10),RI2(10),
     *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
      COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
     *DWDX(10),T1IS(10),PRAT3(10),SS(10),ALFA(10)
      COMMON/VAR12/BETA(10),DELR(10),WPERO(10),ZETAS(10),ZETAR1(20),
     *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
      COMMON/VAR13/ST1(20),IRR(20),R2(20),A2(20),RINC(20),DR(10),
     *BETO(10),STALII(10),AREA2(10),VR1(10)
      COMMON/VAR14/WLBM,PRATS,OMEG
      COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
     *P1(10),TO,TEI,ALI,RESP,XX,ANG20,AMS1(10),S,TN,C,TE,AL,SO,TNO,
     *CO,TEO,U(10),D1I,D1O,D2I,D2O,ANG2I,ALFAX,TI,T,PTO,ALO,AMC
      COMMON/AL2/BETA2(10),BETA1(10),BETAO(10),W2(10),TTE(10),U2(10),
     *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIR,ALR,ALOR,
     *P2(10),WU2(10),W1(10),TEIR,TER,TEOR,DIIR,DIOR,BETAZ,BETAI,ANM,
     *TIR,TR,TOR,STALI(10)
      COMMON/ARF/REE
      COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
     *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
      DATA ALF1/ 10.,15.,20.,25.,30.,40.,50.,60./
      DATA ALFO1/ 40.,50.,60.,70.,80./
      DATA ALFO2/ 80.,90.,100.,120.,150.,170./
      DATA XPO1/  .0570,.0465,.0440,.0428,.0424,
     *            .0530,.0415,.0350,.0330,.0323,
     *            .0495,.0380,.0312,.0296,.0285,
     *            .0475,.0355,.0295,.0267,.0250,
     *            .0440,.0335,.0273,.0245,.0225,
     *            .0420,.0312,.0224,.0205,.0183,
     *            .0420,.0300,.0213,.0181,.0152,
     *            .0420,.0300,.0206,.0155,.0125/
      DATA XPO2/  .0424,.0422,.0420,.0402,.0313,.0000,
     *            .0323,.0320,.0318,.0295,.0200,.0000,
     *            .0283,.0280,.0275,.0250,.0143,.0000,
     *            .0250,.0246,.0242,.0208,.0070,.0000,
     *            .0225,.0216,.0203,.0168,.0000,.0000,
     *            .0183,.0170,.0154,.0106,.0100,.0000,
     *            .0150,.0136,.0104,.0050,-.015,.0000,
     *            .0125,.0099,.0073,.0000,-.020,.0000/
      DATA VIS2,VIS3,CP,EMME,GAM/.000013,.000012,.24,28.97,1.4/
      DATA G,CJ,EXP1,EXP2,ERRE/32.174,778.16,3.5,.2857,53.3459/
      END
      PROGRAM THESS
C
C
      DIMENSION INAM(3)
      COMMON/ABA/BA17,BLEX
      COMMON/CUR/COSL(10)
      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
      COMMON/TRS/TRAS
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
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      COMMON/CO7/ICOR,ICO7,IINC,IAI,ICL,IAN,ICON
      COMMON/MAC/IN
      COMMON/IWI/IND,INZ,IWR
      COMMON/AUS/XCL
      COMMON/CSS/CJ,G,Q1
      COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
     *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
     *ASF,AMS,R1(20)
      COMMON/VAR2/B6(20),ZR,ZS,ARF,R2(20),PR,AMR,VU1(10)
      COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
      COMMON/VAR4/RR1,RR2,RR3,RR1,RR3,RR5,VA2(10)
      COMMON/VAR5/PRA11(10),RINCI(10),ALFA11(10),BETA11(10),ZETA1(10),
     *V2(10),ALFA22(10),BETA22(10)
      COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
     *WR2(10),T2S(10),T2IS(10)
      COMMON/VAR7/TTIS(5),BETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
     *RSTAR(10),AKIS(10),PSIR(10)
      COMMON/VAR8/DR1(10),AMW1(10),AMV2(10),BETET(10),PRAT1T(10),
     *AMR2(10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),
     *X2(10)
      COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
     *S1(10),DSDX1(10),WI1(10),HE(10)
      COMMON/VAR10/WU1(10),DHEDX(10),DSDX2(10),RI1(10),RI2(10),
     *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
      COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
     *DWDX(10),T1IS(10),PRAT3(10),SS(10),ALFA(10)
      COMMON/VAR12/BETA(10),DELR(10),WPERO(10),ZETAS(10),ZETAR1(20),
     *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
      COMMON/VAR13/ST1(20),TRR(20),R2(20),A2(20),RINC(20),DR(10),
     *BETO(10),STALII(10),AREA2(10),VR1(10)
      COMMON/VAR14/WLBM,PRATS,OMEG
      COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
     *P1(10),TO,TEI,ALI,RESP,XX,ANG20,AMS1(10),S,TN,C,TF,AL,SO,TNO,
     *CO,TEO,U(10),D1I,D1O,D2I,D2O,ANG21,ALFAX,TI,T,PTO,ALO,AMC
      COMMON/AL2/BETA2(10),BETA1(10),BETAO(10),W2(10),TTE(10),U2(10),
     *STR,TNIR,HP,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIR,ALR,ALOR,
     *P2(10),WU2(10),W1(10),TEIR,TER,TEOR,D1IR,D1OR,BETAZ,BETAT,ANM,
     *TTR,TR,TOR,STAL1(10)
      COMMON/ARF/REE
      COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
     *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
      DATA INAM /2HSH,2HOR,2HT /
      TRAS=1
      XX=1.25
      CALL EXEC(8,INAM).
      END
C
      SUBROUTINE CHAN(TTO,AMC,PTO,RC,WLBM,WCHAN,WPERO)
      DIMENSION RC(10),WPERO(10)
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/CSS/CJ,G,Q1
      TC=TTO/(1.+(GAM-1.)/2.*AMC*AMC)
      VC=SQRT(GAM*ERRE*G*TC)*AMC
      PC=PTO/(1.+(GAM-1.)*AMC**2/2.)**EXP1
      RHO=PC/ERRE/TC
      AREA=3.1416*(RC(5)**2-RC(1)**2)
      WLBM=RHO*AREA*VC
      WCHAN=WLBM/(PTO*SQRT(G/ERRE/TTO))
      WPERO(1)=0.
      WPERO(2)=.25
      WPERO(3)=.5
      WPERO(4)=.75
      WPERO(5)=1.0
      RETURN
      END
C
      SUBROUTINE STATK  (ALFA1,X,TTO,PTO,AM,T,P,V1,VA1,SI1,SI2,Y,S,DSDX,
     *VU1,PRAT,T1IS,SS,DALF,RSF,DELR,CL,CK,ZETAPS,R,RS1,RS3,RS5,
     *ZETA,DR,ZETAS,AMS,NS,VR1)
      DIMENSION ALFA1(10),X(10),T(10),P(10),V1(10),VA1(10),SI1(10),
     *SI2(10),Y(10),DSDX(10),VU1(10),PRAT(10),T1IS(10),SS(10),S(10),
     *DALDX(10),ALFA(10),ALFAM(10),DALF(10),AMS(10),DALFDX(10),DELR(
     *10),ZETAS(10),ETA(10),ZETAPS(10),R(10),ZETA(10),DR(10),VR1(10)
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/CSS/CJ,G,Q1
      COMMON/IWI/IND,INZ,IWR
      C8=0.0
      C9=0.0
      Q1=2.*CJ*G*CP
      C2=VA1(3)**2/(Q1*TTO)
```

```
      DO 303 I=1,5
      IF(R(I)-RS3) 300,301,302
  300 ZETAS(I)=ZETA(1)+((R(I)-RS1)/(RS3-RS1))*(ZETA(3)-ZETA(1))
      ALFA1(I)=ALFA1(3)+((R(I)-RS3)/(RS1-RS3))*DALF(1)
      ZETAPS(I)=ZETAPS(1)+((R(I)-RS1)/(RS3-RS1))*(ZETAPS(3)-ZETAPS(1))
      GO TO 303
  301 ZETAS(I)=ZETA(3)
      ALFA1(I)=ALFA1(3)
      GO TO 303
  302 ZETAS(I)=ZETA(3)+((R(I)-RS3)/(RS5-RS3))*(ZETA(5)-ZETA(3))
      ALFA1(I)=ALFA1(3)+((R(I)-RS3)/(RS5-RS3))*DALF(5)
      ZETAPS(I)=ZETAPS(3)+((R(I)-RS3)/(RS5-RS3))*(ZETAPS(5)-ZETAPS(3))
  303 CONTINUE
      DO 305 I=1,5
      ETA(I)=1.-ZETAS(I)
      M=I-1
      N=I+1
      IF(I-1) 307,307,309
  307 DALFDX(1)=(ALFA1(2)-ALFA1(1))/(X(2)-X(1))
      GO TO 315
  309 IF(I-5) 311,313,313
  311 DALFDX(I)=.5*((ALFA1(N)-ALFA1(I))/(X(N)-X(I))+(ALFA1(I)-ALFA1(M))/
     *(X(I)-X(M)))
      GO TO 315
  313 DALFDX(5)=(ALFA1(5)-ALFA1(4))/(X(5)-X(4))
  315 TAN1=-2.*TAN(ALFA1(I))
      PROD=TAN1*DALFDX(I)
      SINSQ=-2.*SIN(ALFA1(I))**2/X(I)
      SI1(I)=PROD+SINSQ
  305 CONTINUE
  304 DO 332 J=1,5
      IF(J-1) 306,306,310
  306 IF(NS-1) 317,310,310
  317 DO 308 I=1,5
      SS(I)=0.
  308 SI2(I)=SI1(I)
      GO TO 318
  310 DO 312 I=1,5
      AA=C2*Y(I)**2/COS(ALFA1(I))**2
      AB=(1.-AA)/(1.-AA/ETA(I))
  312 S(I)=ALOG(AB)
  314 DSDX(1)=(S(2)-S(1))/(X(2)-X(1))
      DSDX(2)=0.5*(DSDX(1)+(S(3)-S(2))/(X(3)-X(2)))
      DSDX(3)=.5*((S(4)-S(3))/(X(4)-X(3))+(S(3)-S(2))/(X(3)-X(2)))
      DSDX(4)=.5*((S(5)-S(4))/(X(5)-X(4))+(S(4)-S(3))/(X(4)-X(3)))
      DSDX(5)=(S(5)-S(4))/(X(5)-X(4))
      DO 316 I=1,5
      IF(NS-1) 319,321,321
  319 SS(I)=(1.-COS(ALFA1(I))**2/(C2*Y(I)**2))*DSDX(I)
      GO TO 316
  321 SS(I)=((-COS(ALFA1(I))**2/(C2*Y(I)**2))+SIN(ALFA1(I))**2+COS(AL
     *FA1(I))**2*(CL**2+(DR(I)/2.0)**2)/CL**2)*DSDX(I)+COS(ALFA1(I))**2*
     *CK*2.*RSF*DELR(I)/CL**2
  316 SI2(I)=SS(I)+SI1(I)
  318 SUM1=(SI2(1)+SI2(2))*(X(2)-X(1))/4.
      SUM2=(SI2(2)+SI2(3))*(X(3)-X(2))/4.
      SUM3=(SI2(3)+SI2(4))*(X(4)-X(3))/4.
      SUM4=(SI2(4)+SI2(5))*(X(5)-X(4))/4.
      EN2=-SUM2
      EN1=-SUM2-SUM1
      EN3=SUM3
      EN4=SUM3+SUM4
      Y(2)=EXP(EN2)
      Y(1)=EXP(EN1)
      Y(4)=EXP(EN3)
      Y(3)=1.0
      Y(5)=EXP(EN4)
      IF(IND-1) 332,323,323
  323 IF(J-1) 324,324,320
  320 IF(J-3) 322,324,322
  322 IF(J-5) 332,324,332
  324 WRITE(6,326)
  326 FORMAT (/57H SLINE  C8  C9  ITERATION  I'ALFA  I'DSDX  I'TOTAL
     *  Y)
      DO 330 I=1,5
  328 FORMAT (I4,F4.2,F4.2,I9,F12.4,F9.5,F9.4,2F8.4)
  330 WRITE(6,328) I,C8,C9,J,SI1(I),SS(I),SI2(I),Y(I),ALFA1(I)
  332 CONTINUE
      DO 334 I=1,5
      VA1(I)=VA1(3)*Y(I)
```

```
      VU1(I)=VA1(I)*TAN(ALFA1(I))
      V1(I)=VA1(I)/COS(ALFA1(I))
      VR1(I)=-VA1(I)*DR(I)/2./CL
      V1(I)=SQRT(V1(I)*V1(I)+VR1(I)*VR1(I))
      T(I)=TT0-V1(I)**2/Q1
      T1IS(I)=TT0-(TT0-T(I))/ETA(I)
      P(I)=PT0*(T1IS(I)/TT0)**EXP1
  334 PRA1(I)=P(I)/PT0
  336 DO 352 I=1,5
      AMS(I)=V1(I)/SQRT(GAM*ERRE*G*T(I))
  352 CONTINUE
  356 RETURN
      END
C
      SUBROUTINE ROTO1   (VU1,VA1,RPM,U,BETA1,HE,TTE,PTE,X2,P1,T1,W1,WU1,
     *X1,RS,ZETAR,ZETAPR,RR,DHEDX,DSDX,S,U2,OMEG,RR1,RR2,RR3,FS1,FS2,
     *ZETA,B6,RS1,RS3,RS5,BET0,STALI,BINC,VR1)
      DIMENSION VU1(5),VA1(5),U(5),BETA1(5),HE(5),TTE(5),PTE(5),
     *X2(5),P1(5),T1(5),W1(5),WU1(5),X1(5),RS(5),ZETAR(5),
     *ZETAPR(5),RR(5),DHEDX(5),DSDX(5),S(5),U2(5),ZETA(5),
     *VR1(5),B6(10),BET0(5),STALI(5),BINC(5)
      COMMON/CSS/CJ,G,Q1
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/IWI/IND,INZ,IWR
      C=2.*32.174*778.16*CP
      OMEG=RPM*3.1416/30.
      DO 520 I=1,5
      U(I)=OMEG*RS(I)/12.
      U2(I)=U(I)*RR(I)/RS(I)
      WU1(I)=VU1(I)-U(I)
      BETA1(I)=ATAN(WU1(I)/VA1(I))
      W1(I)=VA1(I)/COS(BETA1(I))
      W1(I)=SQRT(VR1(I)*VR1(I)+W1(I)*W1(I))
      TTE(I)=T1(I)+W1(I)**2/C+(U2(I)**2-U(I)**2)/C
      PTE(I)=P1(I)*(TTE(I)/T1(1))**EXP1
      HE(I)=TTE(I)*.24
      IF(RS(I)-RS3) 512,514,516
  512 ZETAR(I)=ZETA(I)+(RS(I)-RS1)/(RS3-RS1)*(ZETA(3)-ZETA(1))
      GO TO 518
  514 ZETAR(I)=ZETA(3)
      GO TO 518
  516 ZETAR(I)=ZETA(3)+(RS(I)-RS3)/(RS5-RS3)*(ZETA(5)-ZETA(3))
  518 ZETAPR(I)=ZETAR(I)/2.0
  520 CONTINUE
      DSDX(1)=(S(2)-S(1))/(X2(2)-X2(1))
      DSDX(2)=0.5*(DSDX(1)+(S(3)-S(2))/(X2(3)-X2(2)))
      DSDX(3)=0.5*((S(4)-S(3))/(X2(4)-X2(3))+(S(3)-S(2))/(X2(3)-X2(2)))
      DSDX(5)=(S(5)-S(4))/(X2(5)-X2(4))
      DSDX(4)=0.5*(DSDX(5)+(S(4)-S(3))/(X2(4)-X2(3)))
      DHEDX(1)=(HE(2)-HE(1))/(X2(2)-X2(1))
      DHEDX(2)=.5*(DHEDX(1)+(HE(3)-HE(2))/(X2(3)-X2(2)))
      DHEDX(3)=0.5*((HE(3)-HE(2))/(X2(3)-X2(2))+(HE(4)-HE(3))/
     * (X2(4)-X2(3)))
      DHEDX(5)=(HE(5)-HE(4))/(X2(5)-X2(4))
      DHEDX(4)=0.5*(DHEDX(5)+(HE(4)-HE(3))/(X2(4)-X2(3)))
  522 CONTINUE
      RETURN
      END
C
      SUBROUTINE ROTO2   (BETA2,HE,DHEDX,DSDX1,DSDX2,VA2,WU2,W2,VU2,V2,
     *X2,U,YR,ZETAR,RI1,RI2,RI3,RI4,RI,SR1,SR2,AA,SR,TTE,PTE,T2,P2,PRAT2
     *,T2S,INDS,DBET,RPF,DELR,CL,CK,DR,R,RR1,RR3,RR5,NS,WR2)
      DIMENSION BETA2(5),HE(5),DHEDX(5),DSDX1(5),DSDX2(5),VA2(5),
     *WU2(5),W2(5),VU2(5),V2(5),X2(5),U(5),YR(5),ZETAR(5),
     *RI1(5),RI2(5),RI3(5),RI4(5),RI(5),SR1(5),SR2(5),YOLD(5),
     *AA(5),SR(5),TTE(5),PTE(5),T2(5),P2(5),PRAT2(5),T2S(5),
     *DBET(5),BETAM(5),AMR(5),DBETDX(5),BETA(5),DELR(5),RIS(5),
     *DR(5),R(5),WR2(5)
      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
      COMMON/CSS/CJ,G,Q1
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/IWI/IND,INZ,IWR
      INDS=0
      INDS1=0
      C=2.*G*CJ
      Q1=C/VA2(3)**2
      DO 274 I=1,5
      IF(R(I)-RR3) 270,271,273
  270 BETA2(I)=BETA2(3)+(R(I)-RR3)/(RR1-RR3)*DBET(1)
      GO TO 274
```

```
271  BETA2(1)=BETA2(3)
     GO TO 274
273  BETA2(1)=BETA2(3)+(R(I)-RR3)/(RR5-RR3)*DBET(5)
274  CONTINUE
     DBETDX(1)=(BETA2(2)-BETA2(1))/(X2(2)-X2(1))
     DBETDX(5)=(BETA2(5)-BETA2(4))/(X2(5)-X2(4))
     DO 280 I=2,4
     M=I-1
     N=I+1
280  DBETDX(I)=.5*((BETA2(N)-BETA2(I))/(X2(N)-X2(I))+(BETA2(I)-BETA2
    *(M))/(X2(I)-X2(M)))
     DO 10 I=1,5
200  TAN1=-2.*TAN(BETA2(I))
     PROD=TAN1*DBETDX(I)
     SIN1=-2.*SIN(BETA2(I))**2/X2(I)
     RI1(I)=PROD+SIN1+DSDX1(I)
     SR1(I)=-4.*U(3)*COS(BETA2(I))*SIN(BETA2(I))/(VA2(3)*YR(I))
     SR2(I)=2.*U(3)*U(I)*COS(BETA2(I))**2/(VA2(3)**2*YR(I)**2)
     YOLD(I)=YR(I)
     AA(I)=(VA2(3)*YR(I)/COS(BETA2(I)))**2/(C*HE(I))
     RI3(I)=(C*COS(BETA2(I))**2/((VA2(3)*YR(I))**2))*DHEDX(I)
     IF (INDS1-1) 10,250,250
 10  CONTINUE
281  IF(IND-1) 201,282,282
282  WRITE(6,121)(RI1(I),I=1,5)
121  FORMAT(/23H CONSTANT INTEGRAND 1-5, 5F8.5)
     WRITE (6,122)
122  FORMAT(/60H SLINE  INDS1  GRAD S   INT2   INT3    INT4    INT
    *Y VAL)
201  DO 20 J=1,13
     DO 30 I=1,5
     AA(I)=AA(I)*(YR(I)/YOLD(I))**2
     ANUM=1.-AA(I)
     ADEN=1.-AA(I)/(1.-ZETAR(I))
     AB=ANUM/ADEN
     IF (AB) 130,130,30
130  INDS=1
     GO TO 150
 30  SR(I)=ALOG(ANUM/ADEN)
     DSDX2(1)=(SR(2)-SR(1))/(X2(2)-X2(1))
     DSDX2(2)=0.5*(DSDX2(1)+(SR(3)-SR(2))/(X2(3)-X2(2)))
     DSDX2(3)=0.5*((SR(3)-SR(2))/(X2(3)-X2(2))+(SR(4)-SR(3))/
    * (X2(4)-X2(3)))
     DSDX2(5)=(SR(5)-SR(4))/(X2(5)-X2(4))
     DSDX2(4)=0.5*(DSDX2(5)+(SR(4)-SR(3))/(X2(4)-X2(3)))
     DO 40 I=1,5
     SR1(I)=SR1(I)*YOLD(I)/YR(I)
     SR2(I)=SR2(I)*(YOLD(I)/YR(I))**2
     RI2(I)=SR1(I)-SR2(I)
     RI3(I)=RI3(I)*(YOLD(I)/YR(I))**2
     IF(NS-1) 31,32,32
 31  RI4(I)=DSDX2(I)-(DSDX1(I)+DSDX2(I))*C1*HE(I)
    * *(COS(BETA2(I))/YR(I))**2
     GO TO 40
 32  RI4(I)=-(DSDX1(1)+DSDX2(I))*C1*HE(I)*(COS(BETA2(I))/YR(I))**2
     RI5(I)=(DSDX1(I)+DSDX2(I))*(SIN(BETA2(I))**2+COS(BETA2(I))**2
    **((CL**2+(DR(I)/2.0)**2)/CL**2))-COS(BETA2(I))**2*(2.*CK*RRF*
    *DELR(I))/CL**2
     RI4(I)=RI4(I)+RI5(I)
 40  RI(I)=RI1(I)+RI2(I)+RI3(I)+RI4(I)
     SUM1=(RI(1)+RI(2))*(X2(2)-X2(1))/4.
     SUM2=(RI(2)+RI(3))*(X2(3)-X2(2))/4.
     SUM3=(RI(3)+RI(4))*(X2(4)-X2(3))/4.
     SUM4=(RI(4)+RI(5))*(X2(5)-X2(4))/4.
     EN1=-(SUM2-SUM1)
     EN2=-SUM2
     EN4=SUM3
     EN5=SUM3+SUM4
     DO 50 I=1,5
 50  YOLD(I)=YR(I)
     YR(1)=EXP(EN1)
     YR(2)=EXP(EN2)
     YR(3)=1.0
     YR(4)=EXP(EN4)
     YR(5)=EXP(EN5)
     NCOUNT=0
     DO 1001 I=1,5
     IF(YR(I).GT.2.0) YR(I)=2.0
     IF(YR(I).LT.0.2) YR(I)=0.2
1001 CONTINUE
```

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      DO 110 I=1,5
      TEST=ABS(YOLD(I)-YR(I))
      IF(TEST-TOL4) 110,110,119
  110 NCOUNT=NCOUNT+1
      IF(NCOUNT-5) 119,140,119
  119 IF(IND-1) 20,120,120
  120 IF(J-3) 80,100,80
   80 IF(J-6) 90,100,90
   90 IF(J-9) 160,100,160
  160 IF(J-12) 20,100,20
  100 DO 60 I=1,5
  123 FORMAT (I4,I7,F10.5,5F8.4)
   60 WRITE (6,123) I,INDS1,DSDX2(I),RI2(I),RI3(I),RI4(I),RI(I),YR(I)
   20 CONTINUE
  140 DO 70 I=1,5
      VA2(I)=YR(I)*VA2(3)
      W2(I)=VA2(I)/COS(BETA2(I))
      WR2(I)=-VA2(I)*DR(I)/2./CL
      W2(I)=SQRT(W2(I)*W2(I)+WR2(I)*WR2(I))
   70 T2(I)=TTE(I)-W2(I)**2/(0.24*C)
      IF(INDS1-1) 251,149,149
  251 INDS1=INDS1+1
      DO 250 I=1,5
      AMR(I)=W2(I)/SQRT(GAM*ERRE*G*T2(I))
  250 CONTINUE
  149 DO 190 I=1,5
      WU2(I)=VA2(I)*TAN(BETA2(I))
      VU2(I)=WU2(I)+U(I)
      T2S(I)=TTE(I)-(TTE(I)-T2(I))/(1.-ZETAR(I))
      P2(I)=PTE(I)*(T2S(I)/TTE(I))**(GAM/(GAM-1.))
      PRAT2(I)=P2(I)/PTE(I)
  190 CONTINUE
  150 RETURN
      END
C
      SUBROUTINE FLOWR(PRAT,ZETAP,X,WI,PTE,PTO,TTE,TTO,AS,ZS,RS,AR,ZR,
     *RR,M,WCHAN,VA,WPER,CODE,WLRM,R,R,TIPC,A)
      DIMENSION PRAT(10),ZETAP(10),X(10),WI(10),PTE(10),TTE(10),
     *VA(10),WPER(10),B(20),A(10),R(10)
      COMMON/CUR/COSL(10)
      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
      COMMON/MAC/IN
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/CSS/CJ,G,Q1
      COMMON/ARA/RA17,BLEX
      COMMON/IWI/IND,INZ,IWR
      IN=20
      C=BLEX
      A(3)=B(1)+B(2)*R(3)+B(3)*R(3)**2+B(4)*R(3)**3+B(5)*R(3)**4
      F1=1./(C+1.)
      F2=1./(3.*C+1.)
      F3=1./(5.*C+1.)
      F4=1./(7.*C+1.)
      F5=1./(9.*C+1.)
      F6=1./(11.*C+1.)
      PRATCR=(2./(GAM+1.))**(GAM/(GAM-1.))
      PHICR=(2./(GAM+1.))**(1./(GAM-1.))*SQRT(2.*GAM/(GAM+1.))
      DO 420 I=1,5
      IF (PRATCR-PRAT(I)) 400,402,402
  400 XE=1.-PRAT(I)**((GAM-1.)/GAM)
      GO TO 404
  402 XE=1.-PRATCR**((GAM-1.)/GAM)
  404 XE2=XE**2
      XE3=XE**3
      XE4=XE**4
      XEINV=1./(XE-1.)
      HNUM=XEINV+F2+XE*F3+XE2*F4+XE3*F5+XE4*F6
      HDEN=XEINV+F1+XE*F2+XE2*F3+XE3*F4+XE4*F5
      HSTAR=HNUM/HDEN
      XT=(HSTAR-1.)/(HSTAR-1.+ZETAP(I))
      IF (PRATCR-PRAT(I)) 406,408,408
  406 PHI=SQRT(2.*GAM/(GAM-1.)*(PRAT(I)**(2./GAM)-PRAT(I)**
     *((GAM+1.)/GAM)))
      GO TO 410
  408 PHI=PHICR
  410 A(I)=B(1)+B(2)*R(I)+B(3)*R(I)**2+B(4)*R(I)**3+B(5)*R(I)**4
      ARAT=A(I)/A(3)
      IF(M-2) 415,412,415
  412 IF(I-5) 415,414,414
  414 ARAT=ARAT+2.*3.1416*R(5)*TIPC/(ZR*AR*RR*(X(5)-X(4)))
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  415 IF(IND-1) 420,416,416
  416 WRITE(6,418) XI,PHI,ARAT
  418 FORMAT (/5H  XH=, F6.4, 6H  PHI=, F7.5, 7H  ARAT= F6.4)
  420 WI(I)=(PTF(I)/PTO)/SQRT(TTF(I)/TTO)*ARAT*XI*PHI*COSL(I)
      SUM1=(WI(1)+WI(2))*(X(2)-X(1))/2.
      SUM2=(WI(2)+WI(3))*(X(3)-X(2))/2.
      SUM3=(WI(3)+WI(4))*(X(4)-X(3))/2.
      SUM4=(WI(4)+WI(5))*(X(5)-X(4))/2.
      WSUM=SUM1+SUM2+SUM3+SUM4
      IF(M-1) 428,426,428
  426 WREQ=WCHAN/(AS*ZS*RS)
      DIFF=ABS(WREQ-WSUM)
      GO TO 430
  428 WREQ=WCHAN/(AR*ZR*RR)
      DIFF=ABS(WREQ-WSUM)
  430 TAL=TOL1*WREQ
      IF (DIFF-TAL) 432,432,434
  432 VA(3)=VA(3)
      CODE=20.
      GO TO 442
  434 IF(WSUM-WREQ) 436,432,438
  436 CONTINUE
      IF(PRAT(1).LT.PRATCR.AND.PRAT(5).LT.PRATCR) GO TO 470
      VA(3)=VA(3)*(1.00+DIFF/WREQ*1.01)
      GO TO 442
  438 VA(3)=VA(3)*(1.00-DIFF/WREQ*1.01)
  442 WPER(1)=0.
      WPER(2)=SUM1/WSUM
      WPER(3)=(SUM1+SUM2)/WSUM
      WPER(4)=(SUM1+SUM2+SUM3)/WSUM
      WPER(5)=1.0
      IF(IND-1) 450,423,423
  423 WRITE(6,422) (WI(I),I=1,5)
  422 FORMAT(/20H  FLOW INTEGRAND 1-5, F10.5)
      WRITE(6,424) SUM1,SUM2;SUM3,SUM4,WSUM
  424 FORMAT(/15H SUMS 1-4,  WSUM, 5F10.5)
      WRITE (6,440) WSUM,WREQ,VA(3)
  440 FORMAT(35H REF FLOWS,COMPUTED-REQUIRED,AX VAL,2F10.4,F10.2)
      WRITE (6,444) WCHAN,WLBM
  444 FORMAT(/36H REF FLOW RATE CHANNEL-SQUARE INCHES,F8.5,18H FLOW RATE
     *-LBM/SEC,F8.5)
      WRITE (6,446) M
  446 FORMAT (/30H STREAMLINE FLOW FRACTIONS, M=I2)
      WRITE (6,448) X(2),WPER(2),X(3),WPER(3),X(4),WPER(4)
  448 FORMAT(6F10.4)
      GO TO 450
  470 IN=1
  450 RETURN
      END
C
      SUBROUTINE SLINE (RR,X,DWDX,WPER2,WPER1,HE,U,DHEDX,S,DSDX1,
     *ARF,RRF,FC1,FC2,CODE,M,B)
      DIMENSION RR(10),X(10),DWDX(10),WI(10),WPER2(10),WPER1(10),HE(10),
     *DHEDX(10),S(10),DSDX1(10),U(10),B(20)
      COMMON/TOL/TOL1,TOL2,TOL3;TOL4
      COMMON/IWI/IND,INZ,IWR
      N7=0
      SAVE=RR(3)
      CODE=1.
      DO 700 I=1,4
      J=I+1
  700 DWDX(I)=(WPER2(J)-WPER2(I))/(X(J)-X(I))
      N=0
      DO 720 I=2,4
      K=I+1
      J=I-1
      IF (ABS(WPER2(I)-WPER1(I))-TOL2) 716,716,702
  702 IF (WPER2(I)-WPER1(I)) 704,716,708
  704 XN=X(I)+(WPER1(I)-WPER2(I))/DWDX(J)
      IF(M-1) 706,712,706
  706 SL=(HE(K)-HE(I))/(X(K)-X(I))
      DEL=2.*(SL-DHEDX(I))/(X(K)-X(I))
      DHEDX(I)=DHEDX(I)+DEL*(XN-X(I))
      HE(I)=HE(I)+DHEDX(I)*(XN-X(I))
      SL=(S(K)-S(I))/(X(K)-X(I))
      DEL=2.*(SL-DSDX1(I))/(X(K)-X(I))
      DSDX1(I)=DSDX1(I)+DEL*(XN-X(I))
      S(I)=S(I)+DSDX1(I)*(XN-X(I))
      GO TO 712
  708 XN=X(I)-(WPER2(I)-WPER1(I))/DWDX(I)
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      IF (M-1) 710,712,710
  710 SL=(HE(I)-HE(J))/(X(I)-X(J))
      DEL=2.*(DHEDX(I)-SL)/(X(I)-X(J))
      DHEDX(1)=DHEDX(1)+DEL*(XN-X(I))
      HE(I)=HE(I)+DHEDX(I)*(XN-X(I))
      SL=(S(I)-S(J))/(X(I)-X(J))
      DEL=2.*(DSDX1(I)-SL)/(X(I)-X(J))
      DSDX1(I)=DSDX1(1)+DEL*(SN-X(I))
      S(I)=S(I)+DSDX1(I)*(XN-X(I))
  712 RR(1)=XN*SAVE
      GO TO 718
  716 N=N+1
      IF (N-3) 720,730,720
  718 U(I)=U(I)*XN/X(I)
  720 CONTINUE
      DO 722 I=1,5
  722 X(I)=RR(I)/RR(3)
      FC1=RR(3)/SAVE
      FC2=FC1**2
      RRF=RR(3)
      ARF=B(1)+B(2)*RRF+B(3)*RRF**2+B(4)*RRF**3+B(5)*RRF**4
      IF(IND-1) 732,721,721
  721 IF (M-1) 729,732,729
  729 WRITE (6,724)
  724 FORMAT (/47H SLINE  XNEW  HENEW     DHEDX      S-NEW   DSDX1)
      DO 728 I=1,5
  726 FORMAT (I4,F9.4,F9.2,F9.4,F9.6,F9.5)
  728 WRITE (6,726) I,X(I),HE(I),DHEDX(I),S(I),DSDX1(I)
      GO TO 732
  730 CODE=40.
  732 RETURN
      END
C
      SUBROUTINE ALOS1(ZETAS,ZETAPS)
      DIMENSION ZETAS(10),ZETAPS(10)
      COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
     *P1(10),TO,TEI,ALI,BESP,XX,ANG20,AMS1(10),S,TN,C,TE,AL,SO,TNO,
     *CO,TEO,U(10),D1I,D1O,D2I,D2O,ANG2I,ALFAX,TI,T,PTO,ALO,AMC
      COMMON/AL2/BETA2(10),BETA1(10),BETAO(10),W2(10),TTE(10),U2(10),
     *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIR,ALR,ALOR,
     *P2(10),WO2(10),W1(10),TEIR,TER,TEOR,D1IR,D1OR,BETAZ,BETAI,ANM,
     *TIR,TR,TOR,STALI(10)
      COMMON/GAS/CP,GAM,EMME,ERKE,EXP1,EXP2,VIS2,VIS3
      COMMON/CSS/CJ,G,Q1
      COMMON/IWI/IND,INZ,IWR
      COMMON/AUS/XCL
      COMMON/ARE/REE
      COMMON/COZ/ICOR,ICOZ,IINC,IAI,ICL,IAN,ICON
      COMMON/ARA/BA17,BLEX
      COMMON/TRS/TRAS
      DO 6001 MACC=1,5,2
      TRA1=90.-ALFA1(MACC)*57.29578
      TRA2=V1(MACC)*.3048
      TRA3=TTO/1.8
      TRA4=RPM*3.14159/30.*RS(MACC)/12.*.3048
      IF(MACC-3) 6002,6003,6004
 6002 CALL TRAU2 (TRA1,90.,TRA2,TRA3,EMME,GAM,SI,TNI,H,D,TRAS,CI,TRA4,
     *0.,TR16,TRA7,TRA8,TRA9,ZETAS(MACC))
      GO TO 6001
 6003 CALL TRAU2 (TRA1,90.,TRA2,TRA3,EMME,GAM,S,TN, H,D,TRAS,C ,TRA4,
     *0.,TR26,TRA7,TRA8,TRA9,ZETAS(MACC))
      GO TO 6001
 6004 CALL TRAU2 (TRA1,90.,TRA2,TRA3,EMME,GAM,SO,TNO,H,D,TRAS,CO,TRA4,
     *0.,TR36,TRA7,TRA8,TRA9,ZETAS(MACC))
 6001 CONTINUE
      IF(ICOZ.LT.5) GO TO 2026
      DO 2027 MACC=1,5,2
      XY=ZETAS(MACC)/(1.-ZETAS(MACC))
      ZETAS(MACC)=(((1.+XY)/(1.+XY*P1(MACC)/PTO)) **EXP2-1.)/
     *((PTO/P1(MACC))**EXP2-1.)
      IF(ICOZ.EQ.8) ZETAS(MACC)=(((1.+XY)/(1.+XY*PESP))**EXP2-1.)/
     *(1./PESP**EXP2-1.)
 2027 CONTINUE
 2026 CONTINUE
      IF(ICON.NE.3) GO TO 31
   30 DO 32 I=1,5,2
   32 ZETAPS(I)=ZETAS(I)
   31 IF(ICON.NE.2) GO TO 33
      IF(ICOR.EQ.4) ZETAPS(1)=TR16
      IF(ICOR.EQ.4) ZETAPS(3)=TR26
```

```
      IF(ICOR.EQ.4) ZETAPS(5)=TR36
   33 CONTINUE
      IF(ICON.NE.1) GO TO 34
      DO 35 I=1,5,2
   35 ZETAPS(I)=.5*ZETAS(I)
   34 CONTINUE
      DO 66 K=1,5
   66 CONTINUE
      RETURN
      END
C
      SUBROUTINE ALOS2(ZETAR,ZETAPR)
      DIMENSION ZETAPS(10),ZETAS(10),ZETAPR(10),ZETAR(10)
      COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
     *P1(10),TO,TEI,ALI,BESP,XX,ANG2O,AMS1(10),S,TN,C,TF,AL,SO,TNO,
     *CO,TEO,U(10),D1I,D1O,D2I,D2O,ANG2I,ALFAX,TI,T,PTO,ALO,AMC
      COMMON/AL2/BETA2(10),BETA1(10),BETAO(10),W2(10),TTE(10),U2(10),
     *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIR,ALR,ALOR,
     *P2(10),WU2(10),W1(10),TEIR,TER,TFOR,D1IR,D1OR,BETAZ,BETAI,ANM,
     *TIR,TR,TOR,STALI(10)
      COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
     *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
     *ASF,AMS,B1(20)
      COMMON/VAR2/B6(20),ZR,ZS,ARF,B2(20),PR,AMR
      COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
      COMMON/VAR4/BR1,BR2,BR3,RR1,RR3,RR5,VA2(10)
      COMMON/AHA/BA17,BLEX
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/CSS/CJ,G,Q1
      COMMON/IWI/IND,INZ,IWR
      COMMON/AUS/XCL
      COMMON/ARE/REE
      COMMON/COZ/ICOR,ICOZ,IINC,IAI,ICL,IAN,ICON
      COMMON/TR5/TRAS
      IF(ICOR.NE.4) GO TO 6010
      DO 6011 MACC=1,5,2
      TRA1=90.+BETA2(MACC)*57.29578
      TRAX=90.-BETA1(MACC)*57.29578
      GIUD=BETAO(MACC)-BETA1(MACC)
      IF(IINC.EQ.1.AND.GIUD.GE.0.) TRAX=90.-BETAO(MACC)*57.29578
      TRA2=W2(MACC)*.3048
      TRA3=TTE(MACC)/1.8
      TRA4=U2(MACC)*.3048
      IF(MACC-3) 6012,6013,6014
 6012 CALL TRAU2 (TRA1,TRAX,TRA2,TRA3,EMME,GAM,SIR,TNIR,HR,DZ,TRAS,CIR,
     *TRA4,TIPC,TR16,TRA7,TRA8,TRA9,ZETAR(MACC))
      GO TO 6011
 6013 CALL TRAU2 (TRA1,TRAX,TRA2,TRA3,EMME,GAM,SZ, TNR,HR,DZ,TRAS,CR ,
     *TRA4,TIPC,TR26,TRA7,TRA8,YCL ,ZETAR(MACC))
      GO TO 6011
 6014 CALL TRAU2 (TRA1,TRAX,TRA2,TRA3,EMME,GAM,SOR,TNOR,HR,DZ,TRAS,COR,
     *TRA4,TIPC,TR36,TRA7,TRA8,TRA9,ZETAR(MACC))
 6011 CONTINUE
      DH1=CP*TTO*(1.-(P2(3)/PTO)**EXP2)
      PSI=1./(1.-YCL*DH1*G*CJ/U2(3)/WU2(3))
      ZEZE=ZETAR(3)
      DO 6015 MACC=1,5,2
      ZETAR(MACC)=ZETAR(MACC)+(1.-ZEZE)*(1.-PSI*PSI)
 6015 CONTINUE
 6010 CONTINUE
      IF(ICOZ.LT.5) GO TO 2046
      DO 2047 MACC=1,5
      XY=ZETAR(MACC)/(1.-ZETAR(MACC))
      ZETAR(MACC)=(((1.+XY)/( 1.+XY*P2(MACC)/PTE(MACC)))**EXP2-1.)/
     *((PTE(MACC)/P2(MACC))**EXP2-1.)
      IF(ICOZ.EQ.8) ZETAR(MACC)=(((1.+XY)/(1.+XY*BESP))**EXP2-1.)/
     *(1./BESP**EXP2-1.)
 2046 CONTINUE
 2047 CONTINUE
      IF(ICON.NE.3) GO TO 31
   30 DO 32 I=1,5,2
   32 ZETAPR(I)=ZETAR(I)
   31 IF(ICON.NE.2) GO TO 33
      IF(ICOR.EQ.4) ZETAPR(1)=TR16
      IF(ICOR.EQ.4) ZETAPR(3)=TR26
      IF(ICOR.EQ.4) ZETAPR(5)=TR36
   33 CONTINUE
      IF(ICON.NE.1) GO TO 34
      DO 35 I=1,5,2
   35 ZETAPR(I)=.5*ZETAR(I)
```

```
   34 CONTINUE
      ZETAR(2)= ZETAR(1)+(RR(2)-RR1)/(RR3-RR1)*(ZETAR(3)-ZETAR(1))
      ZETAR(4) =ZETAR (3)+(RR(4)-RR3)/(RR5-RR3)*(ZETAR(5)-ZETAR(3))
      ZETAPR(2)=ZETAPR(1)+(RR(2)-RR1)/(RR3-RR1)*(ZETAPR(3)-ZETAPR(1))
      ZETAPR(4)=ZETAPR(3)+(RR(4)-RR3)/(RR5-RR3)*(ZETAPR(5)-ZETAPR(3))
      DO 7001 I=1,5
 7001 CONTINUE
      RETURN
      END
C
      FUNCTION VAVRA(TH,TE,SP)
C     TH=THROAT OPENING
C     TE=TRAILING EDGE THICKNESS
C     SP=BLADE SPACING
      ARG1=TH/SP
      TERM1=ATAN(SQRT(1.-(ARG1**2))/ARG1)
      TERM2=TERM1*180./3.14159
      TERM3=1.-TERM2/90.
      TERM4=(4.*TE/SP)*TERM3
      ARG2=(TH/SP)+TERM4
      VAVRA=ATAN(SQRT(1.-(ARG2**2))/ARG2)
      RETURN
      END
C
C
C
      FUNCTION XPO(ANG1,ANG2)
      COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
     *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
      IF(ANG2-80.) 1,2,3
    1 CONTINUE
      DO 4 I=1,8
      DO 5 J=1,4
    5 Q(J)=C1(J,I)
    4 Y(I)=YC(ANG2,Q,3)
      GO TO 10
    2 CONTINUE
      DO 6 I=1,8
    6 Y(I)=XPO1(5,I)
      GO TO 10
    3 CONTINUE
      DO 7 I=1,8
      DO 8 J=1,3
    8 Q(J)=C2(J,I)
    7 Y(I)=YC(ANG2,Q,2)
   10 CONTINUE
      DO 11 I=1,7
      IF(ANG1.GE.ALF1(I).AND.ANG1.LE.ALF1(I+1)) GO TO 100
      IF(ANG1.LT.ALF1(1)) GO TO 101
      IF(ANG1.GT.ALF1(8)) GO TO 102
   11 CONTINUE
  100 CONTINUE
      XPO=Y(I)+(Y(I+1)-Y(I))/(ALF1(I+1)-ALF1(I))*(ANG1-ALF1(I))
      IF(ANG2.LT.40) XPO=0.09-(0.09-(XPO1(1,I)+XPO1(1,I+1))/2.)*
     *(ANG2-20.)/20.
      RETURN
  101 XPO=Y(1)
      RETURN
  102 XPO=Y(8)
      RETURN
      END
C
      FUNCTION CSIM(V1,TO,EMME,GAM)
      ERRE=848.*9.80665/EMME
      AST=SQRT(2.*GAM/(GAM+1.)*ERRE*TO)
      AMACH=V1/AST
      IF(AMACH.LE.0.8) CSIM=1.
      IF(AMACH.LE.0.8) GO TO 1000
      IF(AMACH.LE.1.1) CSIM=1.-0.22/0.3*(AMACH-0.8)
      IF(AMACH.LT.1.2.AND.AMACH.GT.1.1) CSIM=0.78+0.15/0.1*(AMACH-1.1
      IF(AMACH.GT.1.2) CSIM=0.92+1.5/.2*(AMACH-1.2)
 1000 RETURN
      END
C
      SUBROUTINE CID(ANG1,T,DEL,CSID,PSID,PSIF,HM,DM)
      DIMENSION X(7),Y1(7),Y2(7)
      FF=1.-DEL/T/SIN(ANG1)
      DATA X/15.,20.,25.,30.,45.,60.,90./
      DATA Y1/ 1.06,1.1,1.17,1.225,1.63,2.1,2.45/
      DATA Y2/0.016,0.0315,0.049,0.072,0.159,0.260,0.4 /
```

```
      A=ANG1*180./3.1415
      DO 1 I=1,6
      IF(A.LE.X(1)) Y=1.+0.06*A/15.
      IF(A.GE.X(I).AND.A.LE.X(I+1)) Y=+(Y1(I+1)-Y1(I))/(X(I+1)-X(I))*
     *(A-X(I))+Y1(I)
      IF(A.LE.X(1)) Z=Y2(1)*A/X(1)
      IF(A.GE.X(I).AND.A.LE.X(I+1)) Z= (Y2(I+1)-Y2(I))/(X(I+1)-X(I))*
     *(A-X(I))+Y2(I)
    1 CONTINUE
      IF(A.GT.X(7)) Y=1.
      IF(A.GT.X(7)) Z=1.
      CSID=1.+(Y-1.)*2.*(1.-EF)
      PSID=Z*4.*(1.-EF)*(1.-EF)
      PSIF=0.025/0.09* HM*HM/DM/DM
      RETURN
      END
C
      FUNCTION CSIW(XPO,CSIP,T,ANG1,AH)
      CSIW=XPO*CSIP*T*SIN(ANG1)/AH
      RETURN
      END
C
      FUNCTION CSIR(S,AH,V1,ANG1,UM,XP)
      SL=S/AH
      IF(SL.LE.0.4) XL=XP*0.65/.4*SL
      IF(SL.GT.0.4.AND.SL.LE.0.8) XL=XP*(0.65+0.45/0.4*(SL-.4))
      IF(SL.GT.0.8.AND.SL.LE.1.5) XL=XP*(1.1+0.04/0.7*(SL-0.8))
      IF(SL.GT.1.5) XL=XP*(1.5+0.6/1.7*(SL-1.5))
      ASC=V1*SIN(ANG1)/UM
      XRO=0.025+0.015/0.64*ASC*ASC
      IF(ASC.LT. .2) XRO=.024
      IF(ASC.GT. .95) XRO=.0475
      CSIR=XRO*XL
      RETURN
      END
C
      FUNCTION ALEAK(DELRET,DM,AL,CLE,ALFA1)
      C1=0.82-0.075*DELRET
      ALEAK=C1*(DM+AL)*CLE/DM/AL/COS(ALFA1)
      RETURN
      END
C
C
      SUBROUTINE CHBFT(X,Y,N,A,M,RX,RH,R)
C     DESCRIPTION OF PARAMETERS:
C        X   ARRAY OF ABSCISSAE DIMENSIONED REAL*4 X(N)
C        Y   ARRAY OF ORDINATES DIMENSIONED REAL*4 Y(N)
C        N   NUMBER OF SAMPLE POINTS (INTEGER)
C        A   ARRAY OF THE OUTPUTTED POLYNOMIAL COEFFICIENTS
C             DIMENSIONED AT LEAST A(M+2) (REAL*4)
C        M   ORDER OF DESIRED APPROXIMATING POLYNOMIAL
C        RX  WORK ARRAY DIMENSIONED AT LEAST REAL*4 RX(M+2)
C        RH  WORK ARRAY DIMENSIONED AT LEAST REAL*4 RH(M+2)
C        R   INTEGER WORK ARRAY DINENSIONED AT LEAST R(M+2
C
C    NOTE: DIVIDED DIFFERENCES AND NEWTON'S INTERPOLATING FORMULA IS
C          USED FOR COMPUTING THE POLYNOMIAL COEFFICIENTS.
C
      REAL NEXTHI
      INTEGER RI,RJ,R(1)
      DIMENSION X(1),Y(1),A(1),RX(1),RH(1)
      MPLUS1=M+1
      MPLUS2=M+2
      PREVH=0.0
C     DETERMINE INDEX VECTOR FOR INITIAL REFERENCE SET
      R(1)=1
      R(MPLUS2)=N
      D=(N-1)/MPLUS1
      H=D
      DO 1 I=2,MPLUS1
      R(I)=H+1.0
    1 H=H+D
    2 H=-1.0
C     SELECT M+2 REFERENCE PAIRS AND SET ALTERNATIVE DEVIATION VECTOR
      DO 3 I=1,MPLUS2
      RI=R(I)
      RX(I)=X(RI)
      A(I)=Y(RI)
      H=-H
    3 RH(I)=H
```

```
C     COMPUTE M+1 LEADING DIVIDED DIFFERENCES
      DO 4 J=1,MPLUS1
      I1=MPLUS2
      AI1=A(I1)
      RHI1=RH(I1)
      I=MPLUS1
    5 DENOM=RX(I1)-RX(I-J+1)
      AI=A(I)
      RHI=RH(I)
      A(I1)=(AI1-AI)/DENOM
      RH(I1)=(RHI1-RHI)/DENOM
      I1=I
      AI1=AI
      RHI1=RHI
      I=I-1
      IF(I-J) 4,5,5
    4 CONTINUE
C     EQUATE (M+1) THE DIFFERENCE TO ZERO TO DETERMINE H
      H=-A(MPLUS2)/RH(MPLUS2)
C     WITH H KNOWN, COMBINE THE FUNCTION AND DEVIATION DIFFERENCES
      DO 6 I=1,MPLUS2
    6 A(I)=A(I)+RH(I)*H
C     COMPUTE POLYNOMIAL COEFFICIENTS
      J=M
    7 XJ=RX(J)
      I=J
      AI=A(I)
      JPLUS1=J+1
      DO 8 I1=JPLUS1,MPLUS1
      AI1=A(I1)
      A(I)=AI-XJ*AI1
      AI=AI1
    8 I=I1
      J=J-1
      IF(J-1) 9,7,7
    9 CONTINUE
C     IF THE REFERENCE DEVIATION IS NOT INCREASING MONOTONICALLY
C     THEN EXIT
      HMAX=ABS(H)
      IF(HMAX.GT.PREVH) GO TO 29
      A(MPLUS2) =-HMAX
      RETURN
C     FIND THE INDEX, IMAX, AND VALUE,HIMAX, OF THE LARGEST ABSOLUTE
C     ERROR FOR ALL SAMPLE POINTS
   29 A(MPLUS2)=HMAX
      PREVH=HMAX
      IMAX=R(1)
      HIMAX=H
      J=1
      RJ=R(J)
      DO 110 I=1,N
      IF(I.EQ.RJ) GO TO 11
      XI=X(I)
      HI=A(MPLUS1)
      K=M
   12 HI=HI*XI+A(K)
      K=K-1
      IF(K-1) 112,12,12
  112 HI=Y(I)
      ABSHI=ABS(HI)
      IF(ABSHI.LE.HMAX) GO TO 11
      HMAX=ABSHI
      HIMAX=HI
      IMAX=I
      GO TO 110
   11 IF(J.GE.MPLUS2) GO TO 110
      J=J+1
      RJ=R(J)
  110 CONTINUE
C     IF THE MAXIMUM ERROR OCCURS AT A NONREFERENCE POINT, EXCHANGE THIS
C     POINT WITH THE NEAREST REFERENCE POINT HAVING AN ERROR OF THE
C     SAME SIGN AND REPEAT
      IF(IMAX.EQ.R(1)) RETURN
      DO 14 I=2,MPLUS2
      IF(IMAX.LT.R(I)) GO TO 15
   14 CONTINUE
      I=MPLUS2
   15 NEXTHI=H
      IF((I-I/2*2).NE.0) NEXTHI=-H
      IF(HIMAX*NEXTHI.GE.0) GO TO 115
```

```
      IF(IMAX.GE.R(1)) GO TO 116
      J1=MPLUS2
      J=M
  117 R(J1)=R(J)
      J1=J
      J=J-1
      IF(J-1) 118,117,117
  118 R(1)=IMAX
      GO TO 2
  116 IF(IMAX.LE.R(MPLUS2)) GO TO 120
      J=1
      DO 121 J1=1,MPLUS2
      R(J)=R(J1)
  121 J=J1
      R(MPLUS2)=IMAX
      GO TO 2
  115 R(I)=IMAX
      GO TO 2
  120 R(I-1)=IMAX
      GO TO 2
      END
C
      SUBROUTINE TRAU1
      COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
     *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
C
      DO 6 I=1,8
      DO 7 J=1,5
    7 Y(J)=XPO1(J,I)
      DO 8 J=1,6
    8 Y1(J)=XPO2(J,I)
      CALL CHBFT(ALFO1,Y,5,Q,3,RX,RY,IR)
      CALL CHBFT(ALFO2,Y1,6,Z,3,RX,RY,IR)
      DO 12 J=1,4
      C1(J,I)=Q(J)
   12 C2(J,I)=Z(J)
    6 CONTINUE
      RETURN
      END
C
      SUBROUTINE TRAU2 (ANG1,ANGO,V1,TO,EMME,GAM,T,DEZ,HM,DM,CSIP,S,UM,
     *CL,RPRO,R2,R3,YCL,RTOT)
      CSIP=1.
      R=XPO(ANG1,ANGO)
      R1=CSIM(V1,TO,EMME,GAM)
      ANGZ=ANG1*3.1415/180.
      CALL CID(ANGZ,T,DEZ,CSID,PSID,PSIF,HM,DM)
      R2=CSIW(R,CSIP,T,ANGZ,HM)
      R3=CSIR(S,HM,V1,ANGZ,UM,CSIP)
      RPRO=R*CSIP*R1*CSID+PSIF+PSID
      IF(CL.LE.0.) YCL=0.
      IF(CL.LE.0.) GO TO 1000
      DEL=3.1416-(ANGO+ANG1)*3.1416/180.
      ALF1=1.5708-ANGZ
      YCL=ALEAK(DEL,DM,HM,CL,ALF1)
 1000 RTOT=RPRO+R2+R3
C
      RETURN
      END
      FUNCTION YC(XBAR,Q,M)
      DIMENSION Q(6)
      YC=0
      IF(XBAR.EQ.0.) YC=Q(1)
      IF(XBAR.EQ.0.) GO TO 10

      M1=M+1
      DO 1 I=1,M1
    1 YC=YC+Q(I)*XBAR**(I-1)
   10 CONTINUE
 1000 RETURN
      END
```

```
ASHORT T=00003 IS ON CR00025 USING 00024 BLKS R=0000

      FTN4,L
            PROGRAM SHORT(5)
            DIMENSION INAM(3)
            DIMENSION NAME(3)
      C
      C
            COMMON/ABA/BA17,BLEX
            COMMON/CUR/COSL(10)
            COMMON/TOL/TOL1,TOL2,TOL3,TOL4
            COMMON/TRS/TRAS
            COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
            COMMON/COZ/ICOR,ICOZ,IINC,IAI,ICL,IAN,ICON
            COMMON/MAC/IN
            COMMON/IWI/IND,INZ,IWR
            COMMON/AUS/XCL
            COMMON/CSS/CJ,G,Q1
            COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
           *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
           *ASF,AMS,R1(20)
            COMMON/VAR2/B6(20),ZR,ZS,ARF,R2(20),PR,AMR,VU1(10)
            COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
            COMMON/VAR4/BR1,BR2,BR3,RR1,RR3,RR5,VA2(10)
            COMMON/VAR5/PRAT1(10),RINCI(10),ALFA11(10),BETA11(10),ZETA1(10),
           *V2(10),ALFA22(10),BETA22(10)
            COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
           *WR2(10),T2S(10),T2IS(10)
            COMMON/VAR7/TTIS(5),RETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
           *RSTAR(10),AK1S(10),PSIR(10)
            COMMON/VAR8/DR1(10),AMW1(10),AMV2(10),BETET(10),PRAT1T(10),AMR2(
           *10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),X2(10)
            COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),ST1(10),SI2(10),
           *S1(10),DSDX1(10),WI1(10),HE(10)
            COMMON/VAR10/WU1(10),DHEDX(10),DSDX2(10),RI1(10),RI2(10),
           *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
            COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
           *DWDX(10),T1IS(10),PRAT3(10),SS(10),ALFA(10)
            COMMON/VAR12/BETA(10),DELR(10),WPERO(10),ZETAS(10),ZETAR1(20),
           *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
            COMMON/VAR13/ST1(20),IRR(20),R2(20),A2(20),RINC(20),DR(10),
           *BETO(10),STALII(10),AREA2(10),VR1(10)
            COMMON/VAR14/WLBM,PRATS,OMEG
            COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
           *P1(10),TO,TEI,ALI,BESP,XX,ANG20,AMS1(10),S,TN,C,TE,AL,SO,TNO,
           *CO,TEO,U(10),D1I,D1O,D2I,D2O,ANG2I,ALFAX,TI,T,PTO,ALO,AMC
            COMMON/AL2/BETA2(10),BETA1(10),BETAO(10),W2(10),TTE(10),U2(10),
           *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALTR,ALR,ALOR,
           *P2(10),WO2(10),W1(10),TEIR,TER,TEOR,D1IR,D1OR,BETAZ,BETAI,ANM,
           *TIR,TR,TOR,STALI(10)
            COMMON/ARE/REE
            COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
           *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
            DATA INAM /2HSH,2HOR,2HT /
            DATA NAME /2HPA,2HRT,2H2 /
            CALL TRAU1
            XX=1.25
            BLEX=0.15
            XCL=1.35
      C
      C
            BESP=(1.+(GAM-1.)/2.*.64)**(-GAM/(GAM-1.))
      C
      C
      C
      C
      C **********OPERATING CONDITIONS****************
            PTO=38.22
            TTO=626.18
            RPM=12000.
            PR=2.6
      C **********************************************
      C
      C
      C ********INITIAL APPROXIMATIONS***************
            AMC=.2247
            AMS=.9
            AMR=.7
            VA1(3)=262.58
            VA2(3)=262.58
```

```
C ***********************************************
C
C
C ******SPECIAL INPUT DATA*********************
      TOL1=.01
      TOL2=.01
      TOL3=.01
      TOL4=.01
C
      IND=0
      INZ=0
      IWR=0
      ICOR=4
      IAI=0
C
      IAN=2
      ICL=0
      IINC=1
      ICOZ=6
      ICON=3
C
C *****************************************
C
C *********TURBINE GEOMETRY****************
      A1(1)=.2126
      A1(2)=.22145
      A1(3)=.23035
      A1(4)=.23925
      A1(5)=.24815
      A1(6)=.25705
      A1(7)=.26595
      A1(8)=.27485
      A1(9)=.28375
      A1(10)=.2926
C
      A2(1)=.1912
      A2(2)=.20305
      A2(3)=.21495
      A2(4)=.22685
      A2(5)=.23875
      A2(6)=.25065
      A2(7)=.26255
      A2(8)=.27445
      A2(9)=.28635
      A2(10)=.2983
C
      AL=1.088
      ALI=1.088
      ALO=1.088
C
      C=1.003
      CI=1.003
      CO=1.003
C
      E=2.8065
      EI=2.8065
      EO=2.8065
C
      T=.2252
      TI=.2252
      TO=.2252
C
      TE=.03
      TEI=.03
      TEO=.03
C
      TN=.0186
      TNI=.0186
      TNO=.0186
C
      ALR=1.088
      ALIR=1.088
      ALOR=1.088
C
      CR=1.003
      CIR=1.003
      COR=1.003
C
      ER=2.45
      EIR=2.45
```

```
      EOR=2.45
C
      TR=.2252
      TIR=.2252
      TOR=.2252
C
      TER=.03
      TEIR=.03
      TEOR=.03
C
      TNR=.0186
      TNIR=.0186
      TNOR=.0186
C
      RC(1)=2.764
      RC(5)=3.627
C
      RS(1)=2.764
      RS(5)=3.627
C
      RR(1)=2.693
      RR(5)=3.837
C
      CV=.885
      CK=5.0
      TIPC=.01
      ZS=31.
      ZR=32.
C ***********************************
C
C
      RC(2)=SQRT(RC(5)*RC(5)/4.+3./4.*RC(1)*RC(1))
      RC(3)=SQRT(RC(5)*RC(5)/2.+RC(1)*RC(1)/2.)
      RC(4)=SQRT(3./4.*RC(5)*RC(5)+RC(1)*RC(1)/4.)
      RS(2)=SQRT(RS(5)*RS(5)/4.+RS(1)*RS(1)/4.*3.)
      RS(3)=(RS(1)+RS(5))/2.
      RS(4)=SQRT(((RS(5)**2)*.75)+((RS(1)**2)/4.))
      RR(2)=SQRT(RR(5)*RR(5)/4.+3./4.*RR(1)*RR(1))
      RR(3)=(RR(1)+RR(5))/2.
      RR(4)=SQRT(RR(5)*RR(5)*3./4.+RR(1)*RR(1)/4.)
      DO 3300 I=1,10
      A=I
      R1(I)=RS(1)+(A-1.)/9.*(RS(5)-RS(1))
      R2(I)=RR(1)+(A-1.)/9.*(RR(5)-RR(1))
 3300 CONTINUE
      OI=A1(1)
      OO=A1(10)
      OIR=A2(1)
      OOR=A2(10)
      DO 3711 I=1,10
      IF(RS(3).LE.R1(I)) GO TO 3712
 3711 CONTINUE
 3712 CONTINUE
      I=I-1
      O=A1(I)+(A1(I+1)-A1(I))*(RS(3)-R1(I))/(R1(I+1)-R1(I))
      DO 3713 I=1,10
      IF(RR(3).LE.R2(I))  GO TO 3714
 3713 CONTINUE
 3714 CONTINUE
      I=I-1
      OR=A2(I)+(A2(I+1)-A2(I))*(RR(3)-R2(I))/(R2(I+1)-R2(I))
      H=RS(5)-RS(1)
      D=2.*RS(3)
      S=2.*3.1416*RS(3)/ZS
      SI=2.*3.14165 *RS(1)/ZS
      SO=2.*3.1416*RS(5)/ZS
      SZ=2.*3.1416*RR(3)/ZR
      SIR=2.*3.1416*RS(1)/ZR
      SOR=2.*3.1416*RS(5)/ZR
      DZ=2.*RR(3)
      HR=RR(5)-RR(1)
C
C     STATOR OUTLET ANGLES BY VAVRA METHOD
C
      ALFA1(3)=VAVRA(O,TN,S)
      ANG2I   =VAVRA(OI,TNI,SI)
      ANG2O   =VAVRA(OO,TNO,SO)
C
      DALF(1)=ANG2I-ALFA1(3)
      DALF(3)=0.
```

```
      DALF(5)=ANG20-ALFA1(3)
C
C     ROTOR OUTLET ANGLES BY VAVRA METHOD
C
      BETA2(3)=-1.*VAVRA(OR,TNR,SZ)
      BETAI   =-1.*VAVRA(OIR,TNIR,SIR)
      BETAZ   =-1.*VAVRA(OOR,TNOR,SOR)
C
C
      DBET(1)=BETAI-BETA2(3)
      DBET(3)=0.
      DBET(5)=BETAZ-BETA2(3)
      X1(I)=RS(I)/RS(3)
   10 X2(I)=RR(I)/RR(3)
      RROLD2=RR(2)
      RROLD3=RR(3)
      RROLD4=RR(4)
      RSOLD2=RS(2)
      RSOLD3=RS(3)
      RSOLD4=RS(4)
      RS1=RS(1)
      RS3=RS(3)
      RS5=RS(5)
      RR1=RR(1)
      RR3=RR(3)
      RR5=RR(5)
      CALL CHBFT(R1,A1,10,B1,4,T10,ST1,IRR)
      CALL CHBFT(R2,A2,10,B2,4,T10,ST1,IRR)
      ASF=B1(1)+B1(2)*RS(3)+B1(3)*RS(3)**2+B1(4)*RS(3)**3+B1(5)*RS(3)**4
      ARF=B2(1)+B2(2)*RR(3)+B2(3)*RR(3)**2+B2(4)*RR(3)**3+B2(5)*RR(3)**4
      ASF=.2526
      ARF=.2447
      RSF=RS(3)
      ASFO=ASF
      RSFO=RSF
      RRF=RR(3)
      RRFO=RRF
      ARFO=ARF
C     INPUT PRINTING
C
      WRITE(6,671)
  671 FORMAT(1H1,//60X,12HINPUT PRINTS//40X,50H        R1           A1
     *         R2              A2   /)
      DO 72 I=1,10
      WRITE(6,73) R1(I),A1(I),R2(I),A2(I)
   73 FORMAT(40X,F10.3,F10.4,10X,F10.3,F10.4)
   72 CONTINUE
      WRITE(6,74) ZS,ZR,TIPC,CV,CK
   74 FORMAT(/45X,25HNUMBER OF STATOR BLADES =,F8.0/45X,25HNUMBER OF ROT
     *OR  BLADES =,F8.0/45X,25HROTOR TIP CLEARANCE      =,F8.4/45X,25HAXI
     *AL DISTANCE L          =,F8.2/45X,25HCURVATURE FACTOR K       =,F8.2/
     *//55X,16HBLADING GEOMETRY/)
      WRITE(6,75)
   75 FORMAT(//30X,70H        C          E          T              TE      TN
     *        AL              R   /)
      WRITE(6,76)CI,EI,TI,TEI,TNI,ALI,RS(1),C,E,T,TE,TN,AL,RS(3),CO,EO,
     *TO,TEO,TNO,ALO,RS(5)
   76 FORMAT(30X,7F10.4/22X,6HSTATOR,2X,7F10.4/30X,7F10.4/)
   77 FORMAT(30X,7F10.4/22X,6HROTOR ,2X,7F10.4/30X,7F10.4/)
      WRITE(6,77)CIR,EIR,TIR,TEIR,TNIR,ALIR,RR(1),CR,ER,TR,TER,TNR,ALR,
     *RR(3),COR,EOR,TOR,TEOR,TNOR,ALOR,RR(5)
      WRITE(6,78)
   78 FORMAT(/40X,52HALL DIMENSIONS INDICATED IN THIS TABLE ARE IN INCHE
     *S/)
      WRITE(6,79)ICOR,IAI,IAN,ICOZ,IINC,ICL,ICON
   79 FORMAT(////,40X,27HCORRELATION SYSTEM    ICOR =,I5/61X,6HIAI  =,I5/
     *61X,6HIAN  =,I5/61X,6HICOZ =,I5/,61X,6HIINC =,I5/61X,6HICL  =,I5/6
     *1X,6HICON =,I5)
      WRITE(6,81)CP,EMMF,GAM,VIS2,VIS3
   81 FORMAT(/20X, 91HGAS PROPERTIES             CP          MOLECULAR MASS
     * GAMM        VISCOSITY (1)      VISCOSITY (2)/38X,10H(BTU/LB F),32X,13
     *H(LBM /SEC FT),4X,13H(LBM /SEC FT)//36X,F9.3,5X,F10.3,9X,F7.3,2E15
     *.3/)
      CALL EXEC(8,NAME)
C
      END
```

```
APART2 T=00004 IS ON CR00025 USING 00030 BLKS R=0000

 FTN4,L
       PROGRAM PART2(5)
       DIMENSION NAME(3)
       DIMENSION NAMR(3)
       COMMON/ABA/BA17,BLEX
       COMMON/CUR/COSL(10)
       COMMON/TOL/TOL1,TOL2,TOL3,TOL4
       COMMON/TRS/TRAS
       COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
       COMMON/COZ/ICOR,ICOZ,IINC,IAT,ICL,IAN,ICON
       COMMON/MAC/IN
       COMMON/IWI/IND,INZ,IWR
       COMMON/AUS/XCL
       COMMON/CSS/CJ,G,Q1
       COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
      *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
      *ASF,AMS,B1(20)
       COMMON/VAR2/B6(20),ZR,ZS,ARF,B2(20),PR,AMR,VU1(10)
       COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
       COMMON/VAR4/BR1,BR2,BR3,RR1,RR3,RR5,VA2(10)
       COMMON/VAR5/PRAT1(10),RINCI(10),ALFA11(10),BETA11(10),ZETA1(10),
      *V2(10),ALFA22(10),BETA22(10)
       COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
      *WR2(10),T2S(10),T2IS(10)
       COMMON/VAR7/TTIS(5),BETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
      *RSTAR(10),AKIS(10),PSIR(10)
       COMMON/VAR8/DR1(10),AMW1(10),AMV2(10),BETET(10),PRAT1T(10),
      *AMR2(10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),
      *X2(10)
       COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
      *S1(10),DSDX1(10),WT1(10),HE(10)
       COMMON/VAR10/WU1(10),DHEDX(10),DSDX2(10),RI1(10),RI2(10),
      *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
       COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
      *DWDX(10),T1IS(10),PRAT3(10),SS(10),ALFA(10)
       COMMON/VAR12/BETA(10),DELR(10),WPERO(10),ZETAS(10),ZETAR1(20),
      *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
       COMMON/VAR13/ST1(20),TRR(20),R2(20),A2(20),RINC(20),DR(10),
      *BETO(10),STALII(10),AREA2(10),VR1(10)
       COMMON/VAR14/WLBM,PRATS,OMEG
       COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
      *P1(10),TO,TEI,ALI,BESP,XX,ANG20,AMS1(10),S,TN,C,TE,AL,SO,TNO,
      *CO,TEO,U(10),D1I,D10,D2I,D20,ANG2I,ALFAX,TI,I,PTO,ALO,AMC
       COMMON/AL2/BETA2(10),BETA1(10),BETAO(10),W2(10),TTE(10),U2(10),
      *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALTR,ALR,ALOR,
      *P2(10),WU2(10),W1(10),TEIR,TER,TEOR,D1IR,D1OR,BETAZ,BETAI,ANM,
      *TIR,TR,TOR,STALI(10)
       COMMON/ARE/REE
       COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
      *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
       DATA NAME /2HPA,2HRT,2H2 /

       DATA NAMR/2HPA,2HRT,2H3 /
       DO 67 I=1,5
       U(I)=RPM*3.14159/30./12.*R8(I)
       DR(I)=0.
       DELR(I)=0.
       ZETAS(I)=.10
       ZETAR(I)=.15
       ZETAPS(I)=0.05
       ZETAPR(I)=0.05
       COSL(I)=1.0
       YS(I)=1.0
    67 YR(I)=1.0
       N9=0.
   750 NS=0
       N9=N9+1
  7750 CONTINUE
   100 RS(2)=RSOLD2
       RS(3)=RSOLD3
       DO 530 I=1,5
   530 X1(I)=RS(I)/R8(3)
       ASF=ASFO
       RSF=RSFO
       FS1=1.0
       FS2=1.0
       CALL CHAN (TTO,AMC,PTO,RC,WLBM,WCHAN,WPERO)
       NS=0
```

```
  810 DO 801 K=1,15
      CALL STATR (ALFA1,X1,TTO,PTO,AMS,T1,P1,V1,VA1,ST1,ST2,YS,S1,
     *DSDX1,VU1,PRAT1,T1IS,SS,DALF,RSF,DELR,CV,CK,ZETAPS,RS,RS1,RS3,
     *RS5,ZETAS,DR,ZETA1,AMS1,NS,VR1)
      CALL ALOS1(ZETAS,ZETAPS)
      DO 120 I=1,5
      PTE(I)=PTO
  120 TTE(I)=TTO
      CALL FLOWR(PRAT1,ZETAPS,X1,WI1,PTE,PTO,TTE,TTO,ASF,ZS,RSF,ASF,
     *ZR,RSF,1,WCHAN,VA1,WPER1,CODE,WLBM,B1,RS,TIPC,AREA1)
      IF(IN.EQ.1) AMC=AMC-.01
      IF(IN.EQ.1) GO TO 7750
      IF(CODE-20.) 801,802,801
  801 CONTINUE
  802 CONTINUE
      FC1=1.
      FC2=FC1**2
      ARF=ARFO
      RRF=RROLD3
      RR(2)=RROLD2
      RR(3)=RRF
      RR(4)=RROLD4
      DO 71 I=1,5
      AMS1(I)=V1(I)/SQRT(GAM*ERRE*G*T1(I))
      X2(I)=RR(I)/RR(3)
   71 CONTINUE
      CALL ROTO1 (VU1,VA1,RPM,U,BETA1,HE,TTE,PTE,X2,P1,T1,W1,WU1,X1,
     *RS,ZETAR,ZETAPR,RR,DHEDX,DSDX1,S1,U2,OMEG,BR1,BR2,BR3,FS1,FS2,
     * ZETAR,B6,RS1,RS3,RS5,BETO,STALII,RINCI,VR1)
      CODE=1.
      IMACC=0
  201 DO 200 K=1,14
      CALL ROTO2 (BETA2,HE,DHEDX,DSDX1,DSDX2,VA2,WU2,W2,VU2,V2,X2,U2,
     *YR,ZETAR,RI1,RI2,RI3,RI4,RI,SR1,SR2,AA,SR,TTE,PTE,T2,P2,PRAT2,
     *T2S,INDS,DBET,RRF,DELR,CV,CK,DR,RR,RR1,RR3,RR5,NS,WR2)
      CALL ALOS2(ZETAR,ZETAPR)
      IF (INDS-1) 310,320,310
  320 WRITE (6,36) (AA(I),I=1,5)
      WRITE(6,36) ((AA(I),ZETAR(I),VA2(I)),I=1,5)
   36 FORMAT(35H ENTROPY INDETERMINATE, PRINT AA 1-5,5E12.4/,25X,10HZETAR
     * 1-5,5E12.4/25X,10H VA2    1-5,5E12.4/)
      IND=1
  310 CALL FLOWR(PRAT2,ZETAPR,X2,WI1,PTE,PTO,TTE,TTO,ASF,ZS,RSF,ARF,
     *ZR,RRF,2,WCHAN,VA2,WPER2,CODE,WLBM,B2,RR,TIPC,AREA2)

      IF(IN.EQ.1) AMC=AMC-.01
      IF(IN.EQ.1) GO TO 7750
  200 CONTINUE
  130 CONTINUE
      IMACC=IMACC+1
      IF(IMACC.GE.10) GO TO 220
 4322 FORMAT( /20H  LOOP IN SLINE ROT//5E10.3)
      IF(CODE-40.) 201,220,201
 5000 CONTINUE
  220 DO 221 I=1,5
      DELR(I)=RS(I)-(RC(I)+RR(I))/2.
      DR(I)=RC(I)-RR(I)
  221 COSL(I)=SQRT(CV*CV/(DR(I)**2+CV*CV))
      NS=1
  880 DO 881 K=1,15
      CALL ALOS1(ZETAS,ZETAPS)
      CALL STATR (ALFA1,X1,TTO,PTO,AMS,T1,P1,V1,VA1,ST1,ST2,YS,S1,
     *DSDX1,VU1,PRAT1,T1IS,SS,DALF,RSF,DELR,CV,CK,ZETAPS,RS,RS1,RS3,
     *RS5,ZETAS,DR,ZETA1,AMS1,NS,VR1)
      DO 860 I=1,5
      PTE(I)=PTO
  860 TTE(I)=TTO
      CALL FLOWR(PRAT1,ZETAPS,X1,WI1,PTE,PTO,TTE,TTO,ASF,ZS,RSF,ASF,
     *ZR,RSF,1,WCHAN,VA1,WPER1,CODE,WLBM,B1,RS,TIPC,AREA1)
      IF(IN.EQ.1) AMC=AMC-.01
      IF(IN.EQ.1) GO TO 7750
      IF(CODE-20.) 881,822,881
  881 CONTINUE
  822 CONTINUE
  861 CALL ROTO1 (VU1,VA1,RPM,U,BETA1,HE,TTE,PTE,X2,P1,T1,W1,WU1,X1,
     *RS,ZETAR,ZETAPR,RR,DHEDX,DSDX1,S1,U2,OMEG,BR1,BR2,BR3,FS1,FS2,
     *ZETAR,B6,RS1,RS3,RS5,BETO,STALII,RINC,VR1)
      CODE=1.
  894 DO 896 K=1,10
      CALL ALOS2 (ZETAR,ZETAPR)
```

```
      CALL ROTO2  (BETA2,HF,DHFDX,DSDX1,DSDX2,VA2,WU2,W2,VU2,V2,X2,U2,
     *YR,ZETAR,RI1,RI2,RI3,RI4,RI,SR1,SR2,AA,SF,TTE,PTE,T2,P2,PRAT2,
     *T2S,INDS,DBET,RRF,DELR,CV,CK,DR,RR,RR1,RR3,RR5,NS,WR2)
      IF(INDS-1) 895,320,895
  895 CALL FLOWR(PRAT2,ZETAPR,X2,WT1,PTE,PTO,TTE,TTO,ASF,ZS,RSF,ARF,ZR,
     *RRF,2,WCHAN,VA2,WPER2,CODE,WLBM,B2,RR,TIPC,AREA2)
      IF(IN.EQ.1) AMC=AMC-.01
      IF(IN.EQ.1) GO TO 7750
      IF(CODE-20.) 896,897,896
  896 CONTINUE
  897 CONTINUE
  226 DO 227 I=1,5
  227 PRAT3(I)=PTO/P2(I)
      IND=0
      PRATS=(PRAT3(1)+2.*(PRAT3(2)+PRAT3(3)+PRAT3(4))+PRAT3(5))/8.
      WRITE(1,265) PRATS
  265 FORMAT(1X,'COMPUTED PRESSURE RATIO=',F6.3)
      DIFF=ABS(PR-PRATS)
      TAL=TOL3*PR
      IF(TAL-DIFF) 920,910,910
  910 N11=0
      GO TO 223
  920 CONTINUE
  710 IF(PR-PRATS) 712,712,714
  712 AMC=AMC-DIFF/18.
      GO TO 750
  714 AMC=AMC+DIFF/18.
      GO TO 750
  223 CONTINUE
      CALL EXEC(8,NAMR)
      END
```

```
APART3 T=00004 IS ON CR00025 USING 00042 BLKS R=0000

FTN4,L
      PROGRAM PART3(5)
      DIMENSION NAME(3)
      DIMENSION NAMR(3)
      COMMON/ARA/HA17,BLEX
      COMMON/CUR/COSL(10)
      COMMON/TOL/TOL1,TOL2,TOL3,TOL4
      COMMON/TRS/TRAS
      COMMON/GAS/CP,GAM,EMME,ERRE,EXP1,EXP2,VIS2,VIS3
      COMMON/COZ/ICOR,ICOZ,IINC,IAI,ICL,IAN,ICON
      COMMON/MAC/IN
      COMMON/IWI/IND,INZ,IWR
      COMMON/AUS/XCL
      COMMON/CSS/CJ,G,Q1
      COMMON/VAR1/RC(10),RSOLD2,RSOLD3,RSOLD4,ASFO,RSFO,RRFO,ARFO,
     *RR(10),RROLD2,RROLD3,RROLD4,CV,CK,VA1(10),DALF(10),DBET(10),
     *ASF,AMS,B1(20)
      COMMON/VAR2/B6(20),ZR,ZS,ARF,B2(20),PR,AMR,VU1(10)
      COMMON/VAR3/PTE(10),RS1,RS3,RS5,T2(10)
      COMMON/VAR4/BR1,BR2,BR3,RR1,RR3,RR5,VA2(10)
      COMMON/VAR5/PRA11(10),RINCI(10),ALFA11(10),BETA11(10),ZETA1(10),
     *V2(10),ALFA22(10),BETA22(10)
      COMMON/VAR6/PT2(10),TT2(10),PT1(10),DELH(10),ALFA2(10),VU2(10),
     *WR2(10),T2S(10),T2IS(10)
      COMMON/VAR7/TTIS(5),BETAT(5),ETAT(5),ETAI(10),ETAS(10),ETAR(10),
     *RSTAR(10),AKIS(10),PSTR(10)
      COMMON/VAR8/DR1(10),AMW1(10),AMV2(10),BETET(10),PRAT1T(10),
     *AMR2(10),YS(10),X1(10),AREA1(10),ZETAPS(10),WPER1(10),YR(10),
     *X2(10)
      COMMON/VAR9/ZETAR(10),ZETAPR(10),AS(10),AR(10),SI1(10),SI2(10),
     *S1(10),DSDX1(10),WI1(10),HE(10)
      COMMON/VAR10/WU1(10),DHEDX(10),DSDX2(10),RI1(10),RI2(10),
     *RI3(10),RI4(10),RI(10),SR1(10),SR2(10)
      COMMON/VAR11/YOLD(10),AA(10),SR(10),PRAT2(10),WPER2(10),
     *DWDX(10),T1IS(10),PRAT3(10),SS(10),ALFA(10)
      COMMON/VAR12/BETA(10),DELR(10),WPERO(10),ZETAS(10),ZETAR1(20),
     *ZETAR3(20),ZETAR5(20),R1(20),A1(20),T10(20)
      COMMON/VAR13/ST1(20),IRR(20),R2(20),A2(20),RINC(20),DR(10),
     *BETO(10),STALII(10),AREA2(10),VR1(10)
      COMMON/VAR14/WLBM,PRATS,OMEG
      COMMON/AL1/ALFA1(10),V1(10),TTO,RPM,RS(10),SI,TNI,H,D,CI,T1(10),
     *P1(10),TO,TEI,ALI,BESP,XX,ANG20,AMS1(10),S,TN,C,TE,AL,SO,TNO,
     *CO,TEO,U(10),D1I,D1O,D2I,D2O,ANG2I,ALFAX,TI,T,PTO,ALO,AMC
      COMMON/AL2/BETA2(10),BETA1(10),BETAO(10),W2(10),TTE(10),U2(10),
     *SIR,TNIR,HR,DZ,CIR,TIPC,SZ,TNR,CR,SOR,TNOR,COR,ALIR,ALR,ALOR,
     *P2(10),WU2(10),W1(10),TEIR,TER,TEOR,D1IR,D1OR,BETAZ,BETAI,ANM,
     *TIR,TR,TOR,STALI(10)
      COMMON/ARE/REE
      COMMON/TRA/XPO1(5,8),XPO2(6,8),ALF1(8),ALFO1(5),ALFO2(6),
     *Y(10),Y1(10),Q(6),RX(30),RY(30),IR(30),Z(6),C1(4,8),C2(4,8)
      DATA NAME /2HPA,2HRT,2H2 /

      DATA NAMR/2HPA,2HRT,2H3 /

  999 FORMAT(1H1)
      WRITE(6,999)
      WRITE(6,401)
  401 FORMAT(///27X,' SET      PAGE      RPM      TOTAL/STATIC      INLET
     *TOTAL    INLET TOTAL')
      WRITE(6,402)
  402 FORMAT(   27X,67HNUMBER  NUMBER              PRESSURE RATIO   PRESSU
     *RE     TEMPERATURE)
  403 FORMAT(72X, 5H(PSI), 7X,8H(DEG. R)/)
      J=1
      IS=1
      WRITE(6,405)J,IS,RPM,PR,PTO,TTO
  405 FORMAT(27X,I3,I8,F11.1,F14.3,F14.3,F15.2/)
      WRITE(6,404)
  404 FORMAT(//57X21H STATOR EXIT SOLUTION///)
      WRITE(6,406)
  406 FORMAT(1X,'STREAM     RADIAL        X=R/RM   RADIAL    BLADE     Y=VA
     */VAM       BLADE          LOSS              ZETA*        FLOW RATE')
      WRITE(6,407)
  407 FORMAT(1X,109H LINE     POSITION                  SHIFT   OPENING
     *        EFFICIENCY   COEFFICIENT   CONTINUITY     FRACTION /)
      WRITE(6,411)
  411 FORMAT(12X,4H(IN),13X,4H(IN),5X,4H(IN))
      DO 408 I=1,5
```

```
      PRAT1(I)=1./PRAT1(I)
      ALFA11(I)=ALFA1(I)*57.3
      BETA11(I)=BETA1(I)*57.3
      ALFA2(I)=ATAN(VU2(I)/VA2(I))
      V2(I)=VA2(I)/COS(ALFA2(I))
      V2(I)=SQRT(V2(I)*V2(I)+WR2(I)*WR2(I))
      ALFA22(I)=ALFA2(I)*57.3
      BETA22(I)=BETA2(I)*57.3
      DELH(I)=(U(I)*VU1(I)-U2(I)*VU2(I))/(G*CJ)
      TT2(I)=TTO-DELH(I)/CP
      PT2(I)=P2(I)*(TT2(I)/T2(I))**EXP1
      PT1(I)=P1(I)*(TTO/T1(I))**EXP1
      T2IS(I)=TTO*(P2(I)/PTO)**EXP2
      T2S(I)=TTE(I)*(P2(I)/PTE(I))**EXP2
      TTIS(I)=TTO*(PT2(I)/PTO)**EXP2
      BETAT(I)=PTO/PT2(I)
      ETAT(I)=(TTO-TT2(I))/(TTO-TTIS(I))
      ETAI(I)=(TTO-TT2(I))/(TTO-T2IS(I))
      ETAS(I)=(TTO-T1(I))/(TTO-T1IS(I))
      ETAR(I)=(TTE(I)-T2(I))/(TTE(I)-T2S(I))
      RSTAR(I)=(T1IS(I)-T2IS(I))/(TTO-T2IS(I))
      AKIS(I)=2.*G*CJ*CP*(TTO-T2IS(I))/U(I)**2
      PSIR(I)=SQRT(ETAR(I))
      DR1(I)=RC(I)-RS(I)
      AMW1(I)=W1(I)/SQRT(GAM*ERRE*G*T1(I))
      AMS1(I)=V1(I)/SQRT(GAM*ERRE*G*T1(I))
      AMV2(I)=V2(I)/SQRT(GAM*ERRE*G*T2(I))
      AMR2(I)=W2(I)/SQRT(GAM*ERRE*G*T2(I))
      BETET(I)=PTE(I)/P2(I)
      PRAT1T(I)=PTO/PT1(I)
  408 WRITE(6,409) I,RS(I),X1(I),DR1(I),AREA1(I),YS(I),ETAS(I),ZETA1(I),
     *ZETAPS(I),WPER1(I)
      DELH(10)=0.
      DO 240 I=1,4
      L=I+1
  240 DELH(10)=DELH(10)+.5*(WPER2(L)-WPER2(I))*(DELH(L)+DELH(I))
      HP=DELH(10)*CJ*WLBM/550.
      AMOM=HP*550./OMEG
      THETA=SQRT(TTO/518.4)
      DELTA=PTO/14.7
      HP1=HP/(THETA*DELTA)
      AMOM1=AMOM/DELTA
      RPM1=RPM/THETA
      WLBM1=WLBM*THETA/DELTA
      ETA5=(ETAI(1)+ETAI(5)+2.*(ETAI(2)+ETAI(3)+ETAI(4)))/8.
      BETA6=(BETAT(1)+BETAT(5)+2.*(BETAT(2)+BETAT(3)+BETAT(4)))/8.
      ETA6=(ETAT(1)+ETAT(5)+2.*(ETAT(2)+ETAT(3)+ETAT(4)))/8.
      AKIS5=(AKIS(1)+AKIS(5)+2.*(AKIS(2)+AKIS(3)+AKIS(4)))/8.
      RSTAR5=(RSTAR(1)+RSTAR(5)+2.*(RSTAR(2)+RSTAR(3)+RSTAR(4)))/8.
  409 FORMAT(1X,I4,F12.3,F10.3,F9.4,F9.4,F11.4,F11.4,F14.4,F13.4,F14.4)
      WRITE(6,412)
  412 FORMAT(///22X,23HABSOLUTE VELOCITY (FPS),27X,23HRELATIVE VELOCITY
     *(FPS)//)
  413 FORMAT(1X,6HSTREAM,2X,2(50H  AXIAL      RADIAL    TANGENTIAL    OVER
     *ALL           ),7H WHEEL )
      WRITE(6,413)
      WRITE(6,414)
  414 FORMAT(1X,6H LINE  ,  2(50HCOMPONENT   COMPONENT   COMPONENT     VE
     *LOCITY        ),8HVELOCITY//)
      DO 415 I=1,5
  415 WRITE(6,416) I,VA1(I),VR1(I),VU1(I),V1(I),VA1(I),VR1(I),WU1(I),W1(
     *I),U(I)
  416 FORMAT(I5,2X,2(F8.2,3F12.2,6X),F8.2)
      WRITE(6,418)
  418 FORMAT(///7X,113H        MACH NUMBER                  FLOW ANGLE
     *          TEMPERATURE                PRESSURE                 PRESSURE)
      WRITE(6,419)
  419 FORMAT(    7X,113H                                         (DEG)
     *          (DEG. R)                (PSI)                  RATIO  /)
      WRITE(6,492)
  492 FORMAT(  7H STREAM)
      WRITE(6,420)
  420 FORMAT(7H  LINE ,2(24H    ABSOLUTE  RELATIVE    ),2(24H       TOTAL
     * STATIC      ),24H   TOT/TOT     TOT/STA    /)
      DO 422 I=1,5
  422 WRITE(6,421)I,AMS1(I),AMW1(I),ALFA11(I),BETA11(I),TTO,T1(I),PT1(I)
     *,P1(I),PRAT1T(I),PRAT1(I)
  421 FORMAT(I4,3X,2F10.2,4X,2F10.2,4X,2F10.2,4X,2F10.3,4X,F11.4,F10.4)
      WRITE(6,999)
      WRITE(6,401)
```

```
      WRITE(6,402)
      WRITE(6,403)
  452 FORMAT(//57X,21H  ROTOR EXIT SOLUTION///)
      IS=2
      WRITE(6,405) J,IS,RPM,PR,PTO,TTO
      WRITE(6,452)
      WRITE(6,406)
      WRITE(6,407)
      DO 423 I=1,5
  423 WRITE(6,409)I,RR(I),X2(I),DR(I),AREA2(I),YR(I),ETAR(I),ZETAR(I),
     *ZETAPR(I),WPER2(I)
      WRITE(6,412)
      WRITE(6,413)
      WRITE(6,414)
      DO 424 I=1,5
  424 WRITE(6,416)I,VA2(I),WR2(I),VU2(I),V2(I),VA2(I),WR2(I),WU2(I),W2(I
     *),U2(I)
      WRITE(6,418)
      WRITE(6,419)
      WRITE(6,492)
      WRITE(6,420)
      DO 425 I=1,5
  425 WRITE(6,421) I,AMV2(I),AMR2(I),ALFA22(I),BETA22(I),TT2(I),T2(I),
     *PT2(I),P2(I), BETAT(I),PRAT3(I)
      WRITE(6,491)
  491 FORMAT(///)
      WRITE(6,426)
  426 FORMAT(7H STREAM, 41H   EQUIVALENT    EQUIVALENT     EQUIV/STATIC)
  427 FORMAT(7H LINE   , 38H   TEMPERATURE    INLET          PRESSURE)
  428 FORMAT(   7X,      38H                  PRESSURE         RATIO)
  429 FORMAT(   7X ,        22H     (DEG. R)     (PSI)
      WRITE(6,427)
      WRITE(6,428)
      WRITE(6,429)
      DO 430 I=1,5
  430 WRITE(6,431)I,TTE(I),PTE(I),BETET(I)
  431 FORMAT(I4,F13.2,F15.3,F11.1)
      WRITE(6,999)
      WRITE(6,401)
      WRITE(6,402)
      WRITE(6,403)
      IS=3
      WRITE(6,405) J,IS,RPM,PR,PTO,TTO
      WRITE(6,441)
  441 FORMAT(//45X,31HOVERALL TURBINE CHARACTERISTICS///)
      WRITE(6,442)
  442 FORMAT(102H  STREAM          PRESSURE RATIO             EFFICIENCY
     *      HEAD          BLADE/JET      THEORETICAL       )
      WRITE(6,443)
  443 FORMAT(102H    LINE       TOT/STA     TOT/TOT     TOT/STA        TOT/TOT
     *    COEFFICIENT    SPEED RATIO DEGREE OF REACTION /)
      DO 444 I=1,5
      BLAJE=1./SQRT(AKIS(I))
  444 WRITE(6,445) I,PRAT3(I),BETAT(I),ETAI(I),ETAT(I),AKIS(I),BLAJE,RST
     *AR(I)
  445 FORMAT(I5,F14.4,F11.4,F11.4,F13.4,F12.4,F15.4,F16.4)
      WRITE(6,446)
  446 FORMAT(///53X,24HMASS AVERAGED QUANTITIES///)
  447 FORMAT(52X,13HHORSE POWER =,F10.2,3X,4H(HP))
  448 FORMAT(52X,13HMOMENT      =,F10.2,3X,7H(FT-LB))
  449 FORMAT(52X,13HFLOW RATE   =,F10.2,3X,8H(LB/SEC)//)
  461 FORMAT(43X,22HREFERRED  RPM         =,F10.2)
  462 FORMAT(43X,22HREFERRED HORSE POWER =,F10.2,3X,4H(HP))
  463 FORMAT(43X,22HREFERRED MOMENT      =,F10.2,3X,7H(FT-LB))
  464 FORMAT(43X,22HREFERRED FLOW RATE   =,F10.2,3X,8H(LB/SEC)//)
  465 FORMAT(40X,25HTOTAL/STATIC EFFICIENCY =,F10.4)
  466 FORMAT(40X,25HTOTAL/TOTAL  EFFICIENCY= , F10.4)
  467 FORMAT(36X,29HTOTAL/STATIC PRESSURE RATIO =,F10.4)
  468 FORMAT(36X,29HTOTAL/TOTAL  PRESSURE RATIO =,F10.4//)
  469 FORMAT(34X,31HHEAD COEFFICIENT               =,F10.4)
  471 FORMAT(34X,31HTHEORETICAL DEGREE OF REACTION=,F10.4)
  472 FORMAT(34X,31HBLADE/JET SPEED RATIO          =,F10.4)
  473 FORMAT(34X,31HMACH NUMBER AT STATION 0       =,F10.4)
      WRITE(6,447) HP
      WRITE(6,448) AMOM
      WRITE(6,449) WLBM
      WRITE(6,461) RPM1
      WRITE(6,462) HP1
      WRITE(6,463) AMOM1
      WRITE(6,464) WLBM1
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```
      WRITE(6,465) ETA5
      WRITE(6,466) ETA6
      WRITE(6,467) PRATS
      WRITE(6,468) BETA6
      WRITE(6,469) AKISS
      BLAJES=1./SQRT(AKISS)
      WRITE(6,472) BLAJES
      WRITE(6,471) RSTARS
      WRITE(6,473) AMC
      IF(INZ-1) 400,930,930
  930 IF(N11-1) 400,400,400
  400 CONTINUE
      END
```

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